PB-251 066

A METHODOLOGY FOR TREATING LARGE LOCALIZED EMISSIONS OF REACTIVE POLLUTANTS

A. J. Fabrick, et al

JRB Associates, Incorporated

Prepared for:

National Environmental Research Center

February 1974

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FEBRUARY 1974

PB 251 066

Environmental Monitoring Series

A METHODOLOGY FOR TREATING LARGE LOCALIZED EMISSIONS OF REACTIVE POLLUTANTS

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NATIONAL TECHNICAL
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TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO.
EPA-650/4-74-006

2.

3. RECIPIENT'S ACCESSION NO.

4. TITLE AND SUBTITLE
A Methodology for Treating Large Localized Emissions of Reactive Pollutants

5. REPORT DATE
February 1974

6. PERFORMING ORGANIZATION CODE

7. AUTHOR(S)
A. J. Fabrick, P. I. Nakayama, and E. J. Fredricksen

8. PERFORMING ORGANIZATION REPORT NO.

9. PERFORMING ORGANIZATION NAME AND ADDRESS
JRB Associates, Inc.
1200 Prospect Street
LaJolla, California 92037

10. PROGRAM ELEMENT NO.
1AA009

11. CONTRACT/GRANT NO.
68-02-1238

12. SPONSORING AGENCY NAME AND ADDRESS
Meteorology Laboratory
Environmental Protection Agency
Research Triangle Park, N. C. 27711

13. TYPE OF REPORT AND PERIOD COVERED
Final Report

14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

16. ABSTRACT

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Portions of this document are not fully legible ←

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Reactive Pollutants Air Quality Model Dispersion Model Boundary Layer Model Air Pollution		

18. DISTRIBUTION STATEMENT
Release Unlimited

19. SECURITY CLASS *(This Report)*
Unclassified

20. SECURITY CLASS *(This page)*
Unclassified

21. NO. OF PAGES
149 136

22. PRICE
6.00

m 2220-1 (9-73)

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by

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Contract No. 68-02-1238
Program Element No. 1AA009

EPA Project Officer: Herbert Viebrock

Meteorology Laboratory
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Prepared for

OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

February 1974

This report has been reviewed by the Environmental Protection Agency and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

ABSTRACT

This report presents the results of a study to develop a numerical model to accurately calculate the trajectories and concentrations of reactive pollutants emitted from localized sources. The numerical model employs the solution of the full three-dimensional Navier-Stokes equations along with the solution of the species density equation by summing over Lagrangian mass points. The mass points are transported by the mean wind field and moved with a random walk technique that simulates the turbulent diffusion. The effect of chemical reactions are modeled by reweighting the Lagrangian mass points. The equations are solved for regions of space where terrain features or buildings may cause strong distortions in the flow field.

The numerical techniques are verified by comparisons with analytic formulas, including the boundary layer above a plate and the Gaussian plume. The method was used to calculate photochemically reacting plumes using a simplified inorganic photochemical reaction model.

It is concluded that the numerical model shows promise of being able to assess the impact on air quality of point source emission over complex terrain. Furthermore with the incorporation of a valid photochemical reaction kinetics module, the model developed during this study could be used to construct a parametric study of various plumes in order to quantify the errors introduced by regional models in averaging point sources over large areas.

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ACKNOWLEDGMENTS

The authors would like to express their appreciation to C. W. Hirt and J. L. Cook for their pioneering work on the techniques employed under this contract and for their valuable technical assistance during their study.

This work was supported, in part, by the Environmental Protection Agency under contract (EPA-68-02-1238).

SECTION I

CONCLUSIONS

The transport and dispersion of reactive emissions from point sources has been modeled and incorporated into a numerical solution technique that was developed under this program. The technique shows promise of being able to assess the impact on air quality from point source emissions of reactive pollutants over complex terrain; a capability that has heretofore not been available.

With the incorporation of an accurate photochemical reaction kinetics module, the techniques outlined in this report can be used to estimate the errors introduced by smearing point source emissions over large areas in regional photochemical air quality simulation models.

SECTION II

RECOMMENDATIONS

As will be seen in the text, this program has demonstrated the feasibility of a numerical simulation of reactive plumes over irregular terrain. With the addition of an appropriate photochemical reaction kinetics module, the techniques outlined in this report could be used to estimate the errors introduced by smearing point source emissions over large areas in current regional photochemical air quality simulation models.

In order to utilize the methods developed for the calculation of the impact of localized sources in complex terrain several additional features must be added. Atmospheric density stratification and the dynamics of buoyant plumes must be incorporated. Turbulence models that specify eddy viscosity as a function of time and space should be incorporated. To allow greater generality in specifying terrain features arbitrary boundaries treatment should be developed to complement the existing obstacle blocks and half blocks already encoded.

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SECTION III

INTRODUCTION

The importance of the role played by localized emissions on air quality in a large air basin is evident. A source inventory of the Los Angeles Air Basin, for example, shows that about 20% of the oxides of nitrogen are emitted from point as compared to area sources (mainly attributed to the automobile).[1] As automobile emission standards are made more stringent and as additional fossil fuel power plants are built to meet energy demands the percentage of air pollutants emitted from point sources will increase. Because the pollutants of interest are reactive and their reaction rates are a function of concentration, smearing point source emissions over a large area or prescribing an apriori analytical distribution of initial concentration may result in erroneous estimates of the effect of these emissions on air quality. In order to assess the magnitude of the errors resulting from the approximate treatment of point sources employed in current photochemical simulation models a methodology must be developed to correctly relate point source emissions of reactive pollutants to ambient air quality.

The methods developed under this contract solve two major problems associated with reacting plumes. These problems are the specification of the wind and turbulence fields over complex terrain and the solution of the species density equations, including chemistry. The solutions to these problems are respectively, the direct numerical calculation of the three dimensional wind field and a particle-random walk technique to solve the species density equation. In the former, the full Navier-Stokes equations with appropriate boundary conditions are used, and while the turbulence is not calculated directly its effect on the mean flow and the dispersal of pollutants can be prescribed as a function of space and time by assuming the turbulence to be in a state of equilibrium where the creation of turbulent energy by velocity gradients and decay by molecular viscosity are in balance. In the latter, the density equation, including chemistry is solved by representing pollutant species as discrete particles that move within an Eulerian grid. This technique eliminates the numerical smoothing of diffusion of species concentration inherent in finite difference solutions of the density equation. The turbulent diffusion of pollutants is accomplished by a random walk technique imposed on individual particles and is independent of the Eulerian grid. The standard deviation of the random walk is scaled to the local turbulence intensity. Changes in concentration due to chemical reactions are accomplished by adjusting the masses of the individual particles. The techniques discussed above have been incorporated into a computer code, VARMINT. The discussion of this code is divided into four sections. The first two sections discuss the solutions of the Navier-Stokes equations and the verification of the numerical methods employed. The third section deals with the methods employed to solve the species density equation. The fourth section presents the verification of the particle method used to solve the species density equation and preliminary investigation of reactive plumes using a simplified photochemical reaction mechanism. A program users guide and listing are provided in appendices.

SECTION IV

SOLUTION OF THE HYDRODYNAMIC EQUATIONS

The VARMINT code solves the standard Eulerian incompressible equations using a variation of the Marker and Cell Technique which is similar to that employed by Hirt et. al.[2,3] A pressure iteration is utilized to insure the incompressibility condition. The governing equations are

$$\frac{\partial u_i}{\partial t} + \frac{\partial}{\partial x_j}(u_i u_j) = -\frac{\partial P}{\partial x_i} + \frac{\partial}{\partial x_k}\sigma\frac{\partial u_i}{\partial x_k} + g_i \tag{1}$$

$$\frac{\partial u_j}{\partial x_j} = 0 \quad . \tag{2}$$

In Cartesian coordinates

$$\begin{aligned}
\frac{\partial u}{\partial t} + \frac{\partial u^2}{\partial x} + \frac{\partial uv}{\partial y} + \frac{\partial uw}{\partial z} &= -\frac{\partial P}{\partial x} + \frac{\partial}{\partial x}\sigma\frac{\partial u}{\partial x} + \frac{\partial}{\partial y}\sigma\frac{\partial u}{\partial y} + \frac{\partial}{\partial z}\sigma\frac{\partial u}{\partial z} + g_x \\
\frac{\partial v}{\partial t} + \frac{\partial vu}{\partial x} + \frac{\partial v^2}{\partial y} + \frac{\partial vw}{\partial z} &= -\frac{\partial P}{\partial y} + \frac{\partial}{\partial x}\sigma\frac{\partial v}{\partial x} + \frac{\partial}{\partial y}\sigma\frac{\partial v}{\partial y} + \frac{\partial}{\partial z}\sigma\frac{\partial v}{\partial z} + g_y \\
\frac{\partial w}{\partial t} + \frac{\partial wu}{\partial x} + \frac{\partial wv}{\partial y} + \frac{\partial w^2}{\partial z} &= -\frac{\partial P}{\partial z} + \frac{\partial}{\partial x}\sigma\frac{\partial w}{\partial x} + \frac{\partial}{\partial y}\sigma\frac{\partial w}{\partial y} + \frac{\partial}{\partial z}\sigma\frac{\partial w}{\partial z} + g_z
\end{aligned} \tag{3}$$

$$\frac{\partial u}{\partial y} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z} = 0 \quad . \tag{4}$$

Here P is the ratio of pressure to constant density, σ is a momentum eddy diffusivity, and g_x, g_y, g_z are prescribed body accelerations that arise from gravity, buoyency etc. The region in which computations are to be performed is divided into a set of small rectangular cells having edge lengths Δx, Δy, Δz, which need not be the same for all cells. With respect to this set of computational cells, velocity components are located at cell faces and pressure values are at cell centers as shown in Fig. 1. Cells are labeled with an index (i, j, k), which denotes the cell number as counted from the origin in the x, y, and z directions, respectively.

A time-dependent solution is obtained by advancing the flow field variables through a sequence of time steps of duration Δt. The advancement through one time step is calculated in two stages. The first stage or tilde phase consists of a simple explicit calculation, in which the velocity components $(\tilde{u}, \tilde{v}, \tilde{w})$ are advanced using the previous state of the flow to calculate the accelerations caused by convection, diffusion, body forces, and pressure gradients. This explicit time advancement does not necessarily lead to a velocity field with zero divergence, i.e., to one that insures mass conservation. We can, however, insure incompressibility by adjusting the pressure in each cell in such a way that there is no net mass flow in or out of any cell. Adjusting the pressure in one cell will affect neighboring cells so that this adjustment must be performed iteratively until all cells have achieved a mass change not exceeding some small prescribed amount. The explicit finite difference equations for the tilde phase are given in Appendix A. These equations allow the user to specify doner cell or cell centered convective flux approximations or any combination of the two methods.

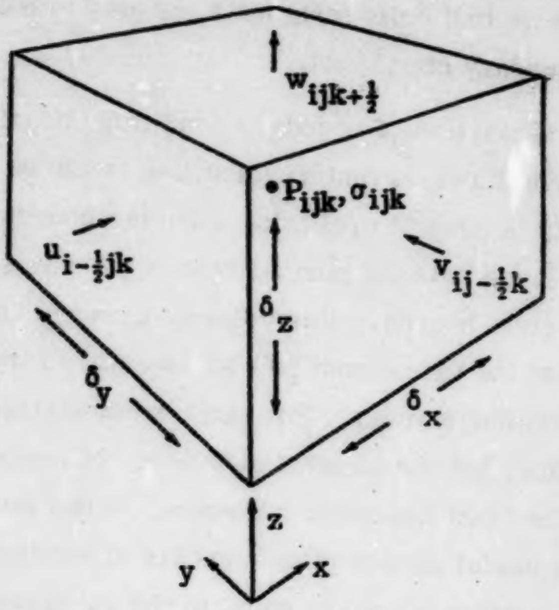

$w_{ijk+\frac{1}{2}}$
$\bullet P_{ijk}, \sigma_{ijk}$
$u_{i-\frac{1}{2}jk}$
$v_{ij-\frac{1}{2}k}$
δ_z
δ_y
δ_x
z
y
x

Figure 1. Location of variables in computational mesh.

BOUNDARY CONDITIONS

Several boundary condition options are available in VARMINT. These include no slip and free slip rigid walls, continuative output walls, and periodic boundaries. For simplicity VARMINT assumes all physical boundaries coincide with cell boundaries. Internal obstacles consisting of cells or half cells (diagonal) are also available with no slip and free slip boundary conditions.

The prescription of boundary conditions consists of a choice for both the normal and tangential velocities at the boundary. The normal velocity is easy to prescribe when the boundary coincides with a cell edge, since it is the normal velocity that is stored for each cell face. For a rigid boundary this velocity is set to zero. If the boundary is periodic the value must be chosen equal to the corresponding velocity one wavelength away. For outflow boundaries there is no unique prescription, but the general idea is to choose boundary conditions that have the least upstream influence. It has been found that for this purpose a useful prescription consists of setting the normal tilde velocity on the outflow boundary equal to the corresponding tilde velocity immediately upstream, and then letting the velocity on the boundary relax as it wishes during the pressure iteration.

The tangential velocities in cells immediately outside the fluid region are set equal to the adjacent velocities inside the fluid when it is desired that the boundary represent a free-slip wall, and they are set equal to the negative of the adjacent fluid velocities when the boundary is to be no slip. In other words, the external velocities tangent to a boundary are chosen to give either vanishing shear or vanishing velocity at a rigid wall. If the boundary is periodic these external velocities are set equal to their counterparts one wavelength away. At an outflow boundary, they are set equal to the adjacent velocities inside the fluid.

The boundary conditions are set after the tilde velocities are calculated and after each pass through the pressure iteration.

The boundary conditions on internal obstacles are the same as for the actual mesh boundaries except that before each pass through the pressure iteration all velocities inside the obstacles are set to zero. This method allows for the correct stress boundary conditions during the tilde calculation and for no divergence boundary conditions during the pressure iteration.

PRESSURE ITERATION

Since tilde equations do not necessarily result in a velocity field that satisfies Eq. (4), some adjustment of the tilde velocities must be made to insure mass conservation.

The iterative process used to modify the tilde velocities is discussed below. In each cell (i, j, k) the value of the velocity divergence D is calculated as:

$$D_{ijk} = \frac{1}{\Delta x_i} \left(u_{i+\frac{1}{2}jk} - u_{i-\frac{1}{2}jk}\right) + \frac{1}{\Delta y_j} \left(v_{ij+\frac{1}{2}k} - v_{ij-\frac{1}{2}k}\right) + \frac{1}{\Delta z_k} \left(w_{ijk+\frac{1}{2}} - w_{ijk-\frac{1}{2}}\right) \quad . \tag{5}$$

The pressure is then changed by an amount

$$\delta P = -\beta D \tag{6}$$

where

$$\frac{1}{\beta} = \frac{1}{\beta_o}\,\frac{\delta D_{ijk}}{\delta P_{ijk}} = \frac{1}{\beta_o}\left[\frac{1}{\Delta x_i}\cdot\frac{2\Delta t}{(\Delta x_i+\Delta x_{i+1})} + \frac{1}{\Delta x_i}\cdot\frac{2\Delta t}{(\Delta x_i+\Delta x_{i-1})}\right.$$

$$+\frac{1}{\Delta y_j}\cdot\frac{2\Delta t}{(\Delta y_j+\Delta y_{j+1})} + \frac{1}{\Delta y_j}\cdot\frac{2\Delta t}{(\Delta y_j+\Delta y_{j-1})} + \frac{1}{\Delta z_k}\cdot\frac{2\Delta t}{(\Delta z_k+\Delta z_{k+1})}$$

$$\left.+\frac{1}{\Delta z_k}\cdot\frac{2\Delta t}{(\Delta z_k+\Delta z_{k-1})}\right]$$

or

$$\beta = \frac{\beta_o}{2\Delta t}\cdot\left[\frac{1}{\frac{1}{\Delta x_i}\left(\frac{1}{\Delta x_i+\Delta x_{i+1}}+\frac{1}{\Delta x_i+\Delta x_{i-1}}\right)}\cdots\right.$$

$$\frac{}{\frac{1}{\Delta y_j}\left(\frac{1}{\Delta y_j+\Delta y_{j+1}}+\frac{1}{\Delta y_j+\Delta y_{j-1}}\right)}\cdots$$

$$\left.\frac{}{\frac{1}{\Delta z_k}\left(\frac{1}{\Delta z_k+\Delta z_{k+1}}+\frac{1}{\Delta z_k+\Delta z_{k-1}}\right)}\right]. \tag{6a}$$

Here, β_o is a relaxation factor, where overrelaxation and underrelaxation correspond to β_o greater than or less than unity. For stability in the iteration, β_o must remain less than 2.

Once ΔP has been calculated it is necessary to add it to the total pressure P_{ijk} and to adjust the velocities:

$$
\begin{aligned}
u_{i+\frac{1}{2}jk} &\rightarrow u_{i+\frac{1}{2}jk} + \left(\frac{2\Delta t}{\Delta x_i + \Delta x_{i+1}}\right) \delta P \quad , \\
u_{i-\frac{1}{2}jk} &\rightarrow u_{i-\frac{1}{2}jk} - \left(\frac{2\Delta t}{\Delta x_i + \Delta x_{i-1}}\right) \delta P \quad , \\
v_{ij+\frac{1}{2}k} &\rightarrow v_{ij+\frac{1}{2}k} + \left(\frac{2\Delta t}{\Delta y_j + \Delta y_{j+1}}\right) \delta P \quad , \\
v_{ij-\frac{1}{2}k} &\rightarrow v_{ij-\frac{1}{2}k} - \left(\frac{2\Delta t}{\Delta y_j + \Delta y_{j-1}}\right) \delta P \quad , \\
w_{ijk+\frac{1}{2}} &\rightarrow w_{ijk+\frac{1}{2}} + \left(\frac{2\Delta t}{\Delta z_k + \Delta z_{k+1}}\right) \delta P \quad , \\
w_{ijk-\frac{1}{2}} &\rightarrow w_{ijk-\frac{1}{2}} - \left(\frac{2\Delta t}{\Delta z_k + \Delta z_{k-1}}\right) \delta P \quad .
\end{aligned}
\tag{7}
$$

This process is repeated successively in all cells until no cell has a magnitude of D greater than ϵ. Where ϵ is a function of the magnitude of the velocities calculated.

When the iteration has converged, the adjusted velocities satisfy the mass conservation condition (4), and this completes the necessary calculations for advancing the flow field through one cycle in time.

A flow diagram of the hydrodynamics routine of VARMINT is given in Figure 2.

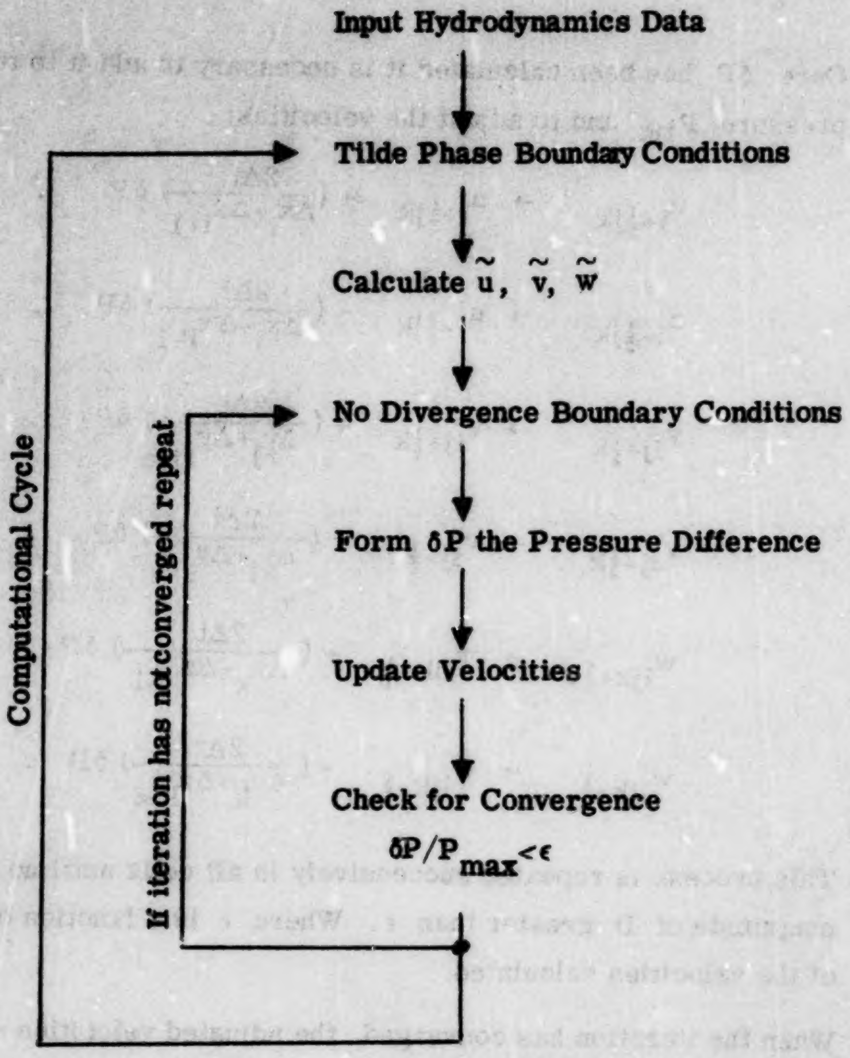

Input Hydrodynamics Data
Tilde Phase Boundary Conditions
Calculate $\tilde{u}$, $\tilde{v}$, $\tilde{w}$
No Divergence Boundary Conditions
Form δP the Pressure Difference
Update Velocities
Check for Convergence
$\delta P/P_{max} < \epsilon$
Computational Cycle
If iteration has not converged repeat

Figure 2. Flow diagram for hydrodynamics routine.

NUMERICAL STABILITY

The basic restriction on the size of the time step, Δt, is that the fluid must not be permitted to flow across more than one computation cell in one time step, that is

$$\Delta t < \min \frac{\Delta x}{|u|}, \frac{\Delta y}{|v|}, \frac{\Delta z}{|w|} \tag{8}$$

This is both a numerical accuracy condition (because the tilde equations assume exchanges between adjacent cells only) and a numerical stability condition.

The VARMINT code may be used either with donor cell or with centered difference for the convection term. When centered difference is used, the equations will be unstable unless the kinematic viscosity, σ, is approximately

$$\sigma > \frac{\Delta t}{2} \max \left[u^2, v^2, w^2\right] \tag{9}$$

When donor cell is used this restriction may be relaxed.

Finally, when low Reynolds number flows are simulated the time step may be restricted by the condition

$$\Delta t < \frac{1}{\nu} \frac{1}{2\left(\frac{1}{\Delta x^2} + \frac{1}{\Delta y^2} + \frac{1}{\Delta z^2}\right)} \tag{10}$$

In analogy with the interpretation of equation (8) this restriction can be described as limiting the distance over which momentum diffuses during one time step to less than one cell width.

SECTION V

VERIFICATION OF THE NUMERICAL SOLUTION

Several qualitative checks were made in order to determine if the methodology incorporated into VARMINT was encoded correctly.

As a check on the variable zoning feature of the code as well as on the diffusion, advection and boundary condition sections, a laminar boundary layer building over a flat plate was calculated.

The grid used for this problem is shown in Figure 3. Initial conditions for the problem shown in Figure 4 is unit velocity over the plate. Figure 5 shows the flow after 150 cycles when the boundary layer has been established. An examination of the results of this problem is shown in Figure 6. The u velocity is plotted as a function of height for three locations at the front, middle and rear of the plate. Note the linear gradient in velocity at the plate and the increase in boundary layer thickness with increasing distance from the front of the plate. To the extent that comparison with the analytic solution is possible these results show good agreement.

The check of the internal obstacles was accomplished by calculating the flow over a flat plate with a notch. The first problem shown in Figures 7-9 is a notch formed by rectangular obstacles. The flow is from left to right with unit velocity over the plate and zero velocity in the notch. The flow at the left boundary is maintained at unity throughout the calculation. Figure 7 shows the computational grid with the plate and notch indicated. Figures 8 and 9 show the resultant velocity vectors at cycles 1 and 21 respectively. Note that by cycle 21 the rotational flow inside the notch has been established. Notice also that the velocity vectors at the left are tilted upward, indicating a small upward component of velocity. This is the start of the boundary layer development.

Diagonal obstacles were also incorporated into the code and checked. Figures 10 and 11 show the results of the calculation of a flat plate with a V notch. The initial conditions were similar to the rectangular notch problem with unit velocity above the plate and zero velocity in the notch. Although too small to see in Figure 11, a rotational flow field has been established at the bottom of the notch.

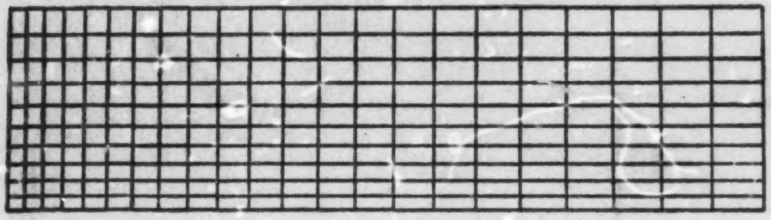


Figure 3. Grid used for laminar boundary layer calculation.

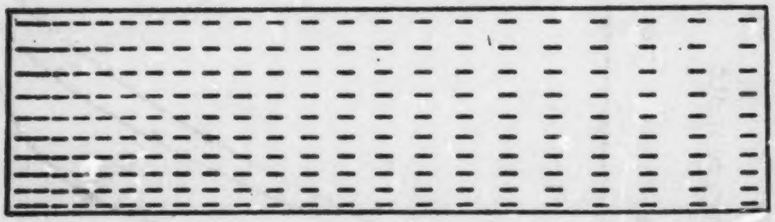


Figure 4. Initial velocity field for laminar boundary layer calculation.

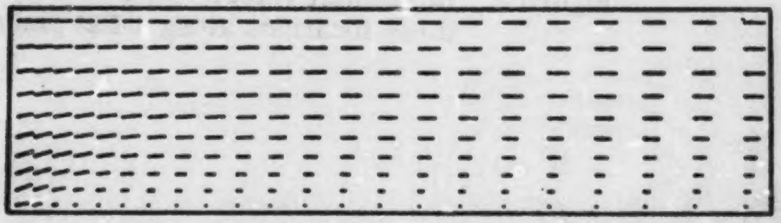


Figure 5. Velocity vectors after 150 computational cycles.

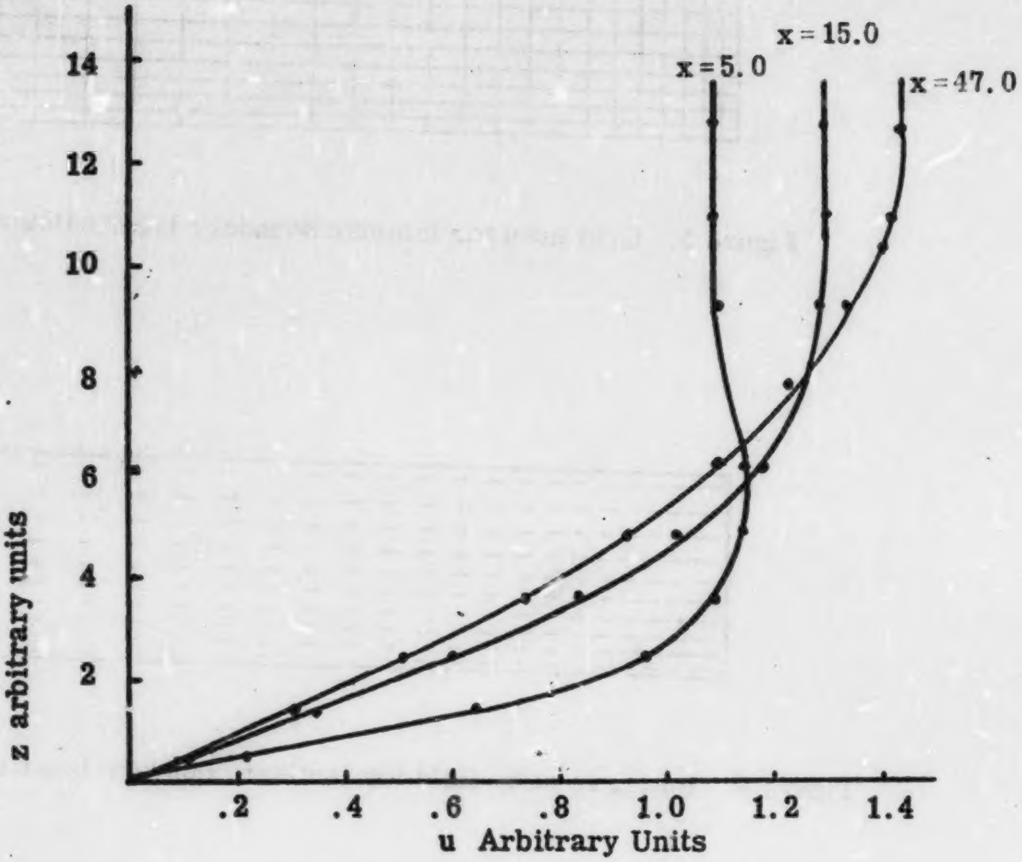


Figure 6. Horizontal velocity as a function of height for three locations along a flat plate.

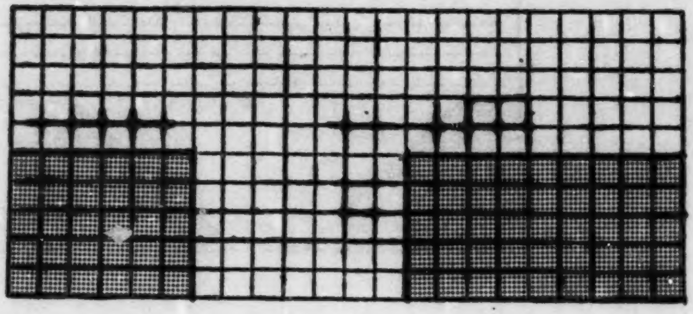


Figure 7. Computational grid for plate over notch calculation.

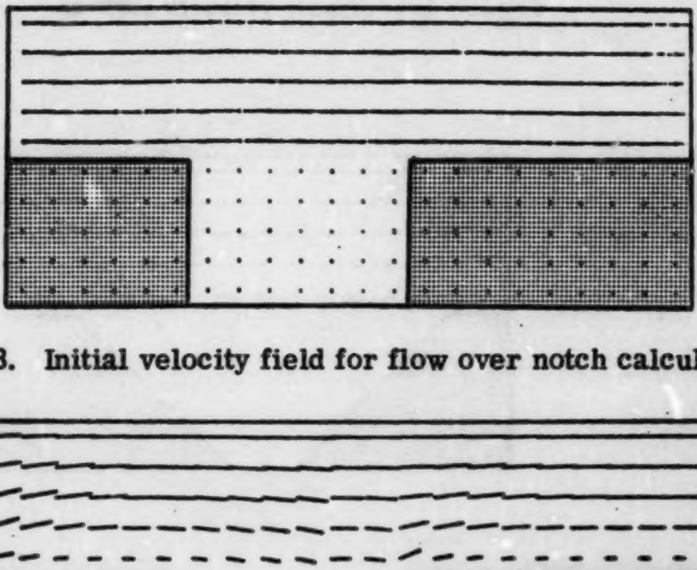


Figure 8. Initial velocity field for flow over notch calculation.

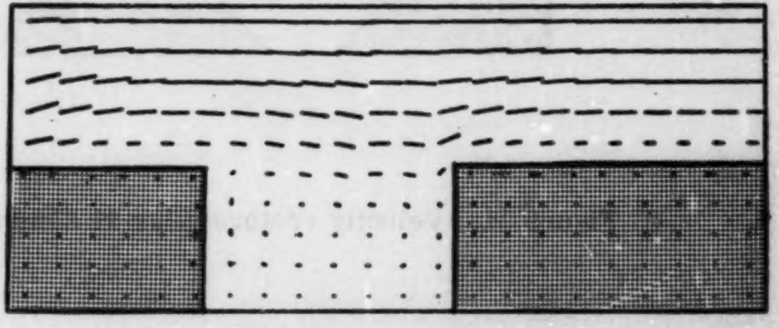


Figure 9. Velocity vectors after twenty-one cycles of computation.

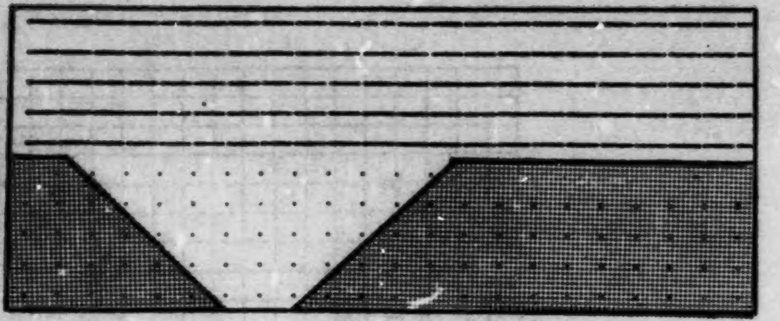


Figure 10. Initial velocity field for V notch problem.

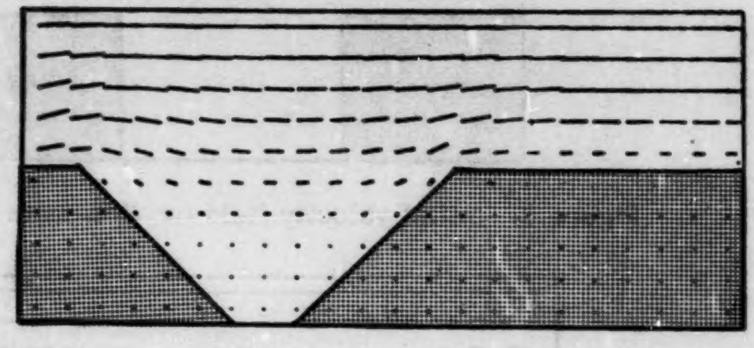


Figure 11. Velocity vectors after 16 computational cycles.

SECTION VI

SOLUTION OF THE DENSITY EQUATION USING PARTICLES

The equation describing turbulent atmospheric diffusion including pollutant sources and chemical reactions,

$$\frac{\partial c}{\partial t} = -\frac{\partial}{\partial x_i} u_i c + \frac{\partial}{\partial x_j} k_{jk} \frac{\partial c}{\partial x_k} + S + R \qquad (11)$$

equates the time rate of change of concentration $\partial c/\partial t$, to the advective rate of change of $-(\partial/\partial x_i) u_i c$, due to the mean velocity field plus the gradient of the turbulent flux with the position dependent eddy diffusivity (k_{ij}), $(\partial/\partial x_j) k_{jk} (\partial c/\partial x_k)$, plus source of concentration, S, plus the change in concentration by chemical reactions, R.

The VARMINT code uses Lagrangian point particles to represent pollutant mass, so that Eulerian species concentration is obtained by summing the masses of the appropriate species in any volume of interest. Changes in particle position are calculated to simulate pollutant mass transport due to both advection and diffusion as specified by the turbulent atmospheric diffusion equation. In addition, changes in particle mass are calculated to simulate changes in pollutant concentration due to chemical reactions.

This technique was developed by Sklarew et al[4] and modified by Hotchkiss and Hirt.[5] In the limit of a large number of particles, equation (11) is solved without the numerical errors introduced by Eulerian finite difference techniques. To simulate advection and diffusion the particles are moved an increment dx_i in the i^{th} direction where,

$$dx_i = u_i\,dt + dw_i \qquad (12)$$

This increment is composed of two parts. The fluid velocity times the time step simulates the advection, while dw_i is a random displacement which simulates turbulent diffusion.

The random displacement dw_i is a variable whose average value is zero and whose variance is equal to $(2k_{ii}\, dt)^{\frac{1}{2}}$. This method developed by Hotchkiss and Hirt[5] approximates the process of eddy diffusion as a random walk scaled to the local eddy diffusivity. This technique cannot directly model the effect of the off diagonal terms in the eddy diffusion tensor k_{ij}, however if these terms are significant (i.e. comparable in magnitude to the diagonal terms) we note that a symmetric tensor can be brought into diagonal form by an orthogonal transformation. Therefore a rotation can always be defined such that the eddy diffusion tensor is diagonal. Thus the random movement of the particles can be done in the rotated frame.

Localized sources are modeled by emitting new particles of the appropriate mass and number densities each cycle. For a source strength Q(gm/sec), a time step of Δt (seconds) and a particle mass m, the number of particles added each cycle is $Q \cdot n/m$. The particle mass m must be chosen so that the total number of particles are large enough to accurately solve equation (11) yet minimize computer run time and storage requirements. For each localized source about 10 to 100 particles emitted per cycle seems to satisfy these criteria.

The concentration of a species is determined by summing the mass of the particles inside a prescribed fluid volume and then dividing by that volume. In the current version of VARMINT the fluid volumes chosen correspond to the cells used in the hydro calculation although this is not required. For computations involving a single species, volume weighting the mass of a particle in the neighborhood of a point where the concentration is required can eliminate discontinuous jumps in the concentration as a mass particle enters and leaves a fluid volume, however this procedure leads to additional diffusion-like errors when chemistry involving multiple species is present.

Once the concentration of all the relevant species in a fluid element are known, the chemical reactions over a time period Δt can be solved and new concentrations computed. Any method of solution of the chemical rate equations is allowed. The VARMINT code treats the chemistry as a "black box" into which is entered Δt and the species concentrations, and from which the concentrations at time plus Δt is returned. Each particle mass is then adjusted so that

$$m^{n+1} = m^n \bullet \frac{c^{n+1}}{c^n}$$

where m^{n+1} is the particle mass at time t plus Δt, m^n is the particle mass at time t.

Multiple species can be handled in two ways. Each specie can be treated as individual particles or each particle can have multiple masses representing each specie associated with its location. Both methods seem to give the same accuracy while the second method saves both computer time and storage by reducing the total number of particles required.

Boundary conditions for the particles are handled in a manner consistent with the boundary conditions in the hydrodynamics section of VARMINT.

Rigid walls and obstacles are treated by reflecting the particles, continuitive boundaries are treated by allowing the particle to leave the computational mesh and periodic boundaries are treated by allowing the particle to leave the computation mesh and return at the other end of the mesh.

SECTION VII

VERIFICATION OF THE PARTICLE ROUTINE

The initial validation of the particle section of VARMINT was done by comparing the VARMINT calculation of a point source in a uniform wind field with the analytic solution of an inert Gaussian plume. The inert plume calculations was made to assess the advection, diffusion, concentration and boundary condition sections of the code. Initially, difficulties were experienced because without diffusion in the downwind direction all the particles emitted during a particular time step were constrained to have the same downwind coordinate, causing them to "line up." Emitting the particles throughout the time step instead of in a single puff corrected this difficulty. This effect is illustrated in Figure 12. The calculation illustrated on the top of Figure 12 is compared with the Gaussian formula in Figure 13. The concentrations are in general units of mass per length^3. The solid lines are the analytic results computed from the Gaussian formula. The plotted points represent the average value of the computed concentrations while the bars associated with each point represent the standard deviation of concentration values about this mean value. Both ground level concentration and concentrations at the level at which the plume was emitted are presented for both the down wind and the cross wind direction. Additionally the variation in concentration with height is also plotted. In all plots the mean values of the VARMINT calculation agrees with the Gaussian formula.

To test the method for adjusting particle masses due to changes by chemical reactions the simple rate equation $dC/dt = -\lambda C$ was chosen

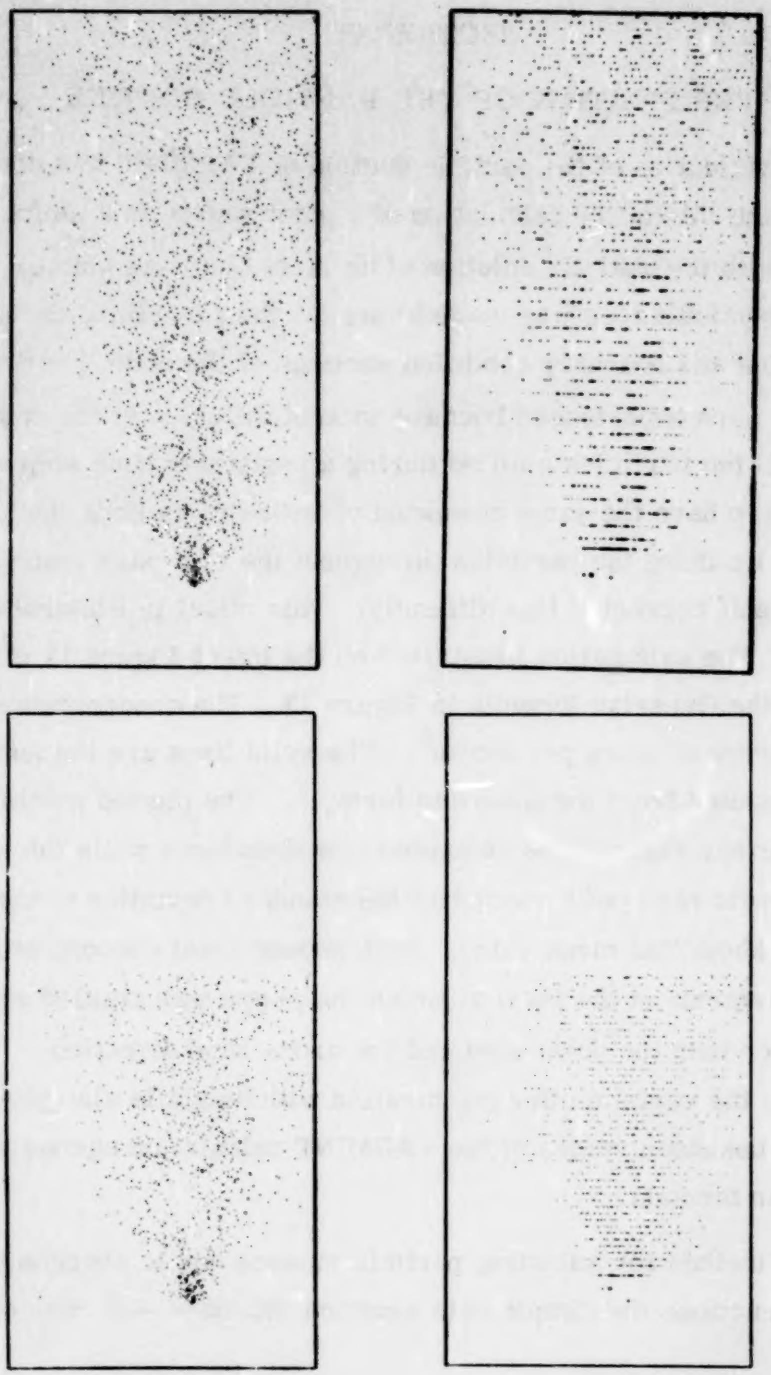


Figure 12. Particle Locations during a VARMINT Simulation of a Gaussian Plume with (Top Two Figures) and without (Bottom Two Figures) Subcycle Staggering.

$$C = \frac{Q}{2\pi\sigma_y\sigma_z\bar{u}} \exp(-y^2/2\sigma_y^2) \{\exp(-(z-H)^2/2\sigma_z^2) + \exp(-(z+H)^2/2\sigma_z^2)\}$$

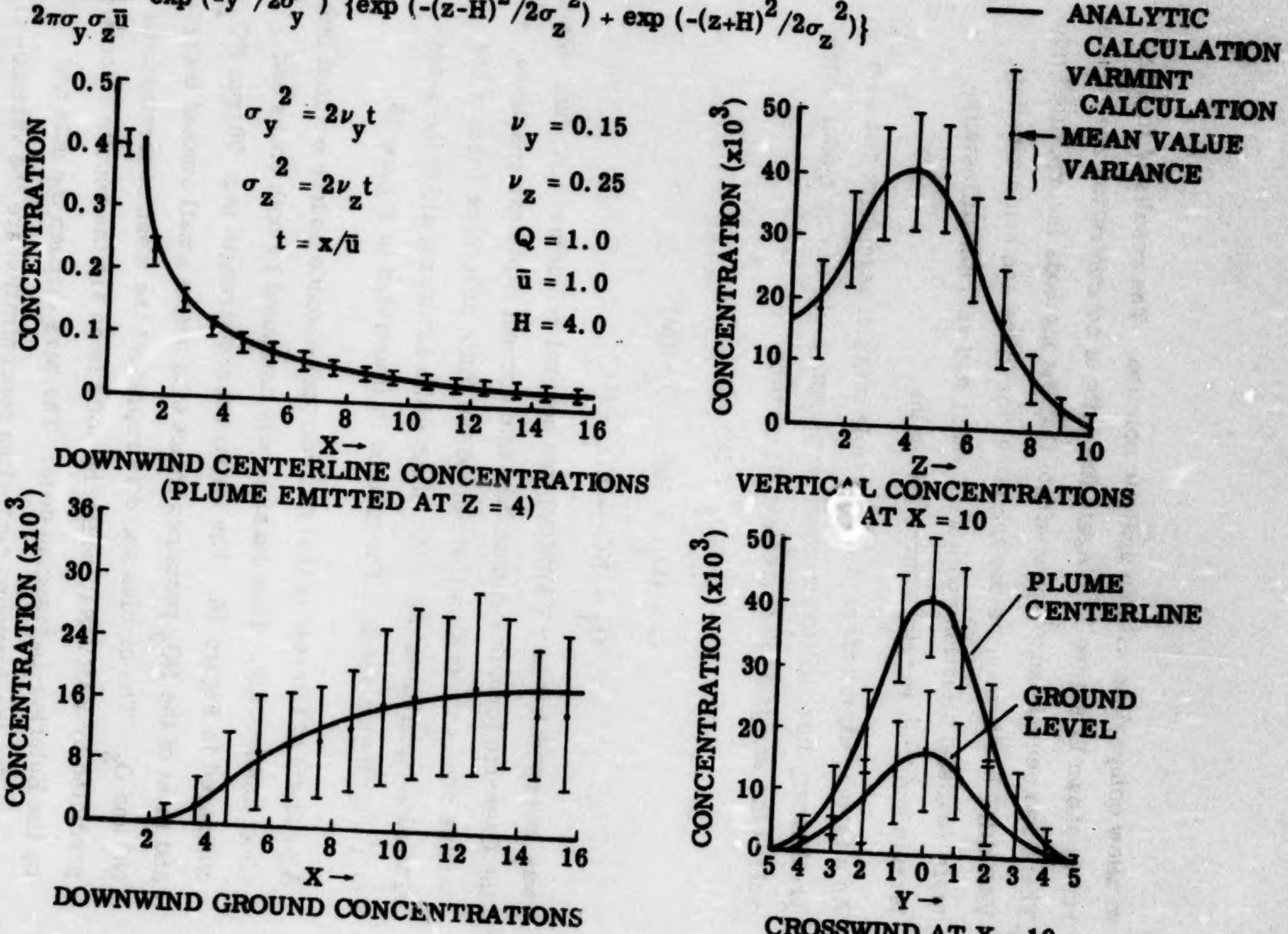


Figure 13. Comparison of VARMINT Calculations and Analytic Solution for a Point Source

to allow comparison with an analytic solution. The results of this test run is shown in Figure 14. Again the units of concentration are general. These two comparisons demonstrate that the methods incorporated into VARMINT can reproduce the analytical formulas and could simulate more realistic situations with wind shear and variable diffusivity, terrain and time varying source strengths.

As a further examination of the particle mass change logic and as a preliminary introduction to reactive plumes a chemistry model which solved the inorganic photochemical reactions

$$(h\nu) + NO_2 \rightarrow NO + O$$

$$O + (O_2) + (M) \rightarrow O_3 + (M)$$

$$O_3 + NO \rightarrow NO_2 + (O_2)$$

was incorporated into VARMINT and several problems were run. Since the Gaussian formulas cannot take into account nonlinear reactions, a simple code was written that solved the finite difference form of the diffusion equation in the $y - z$ plane while advancing along the x-axis in a Lagrangian sense. The method is illustrated in Figure 15.

A problem of interest is that of a nitrogen-dioxide source emitted into clear ambient air. This example was computed by both codes and compared in Figure 16. The initial source strength was 90 ppm NO_2, and most of the NO_2 remained intact with only a small amount becoming NO and O_3. The circles and dots represent the mean concentrations predicted by VARMINT, while the solid lines are the results calculated by the Eulerian-Lagrangian code. The bars through the dots and circles for the downwind centerline concentration are the variance of

$$C = \frac{Q}{2\pi\sigma_y\sigma_z\bar{u}} \exp(-y^2/2\sigma_y^2)\,\{\exp(-(z-H)^2/2\sigma_z^2) + \exp(-(z+H)^2/2\sigma_z^2)\}\,\exp(-\lambda t)$$

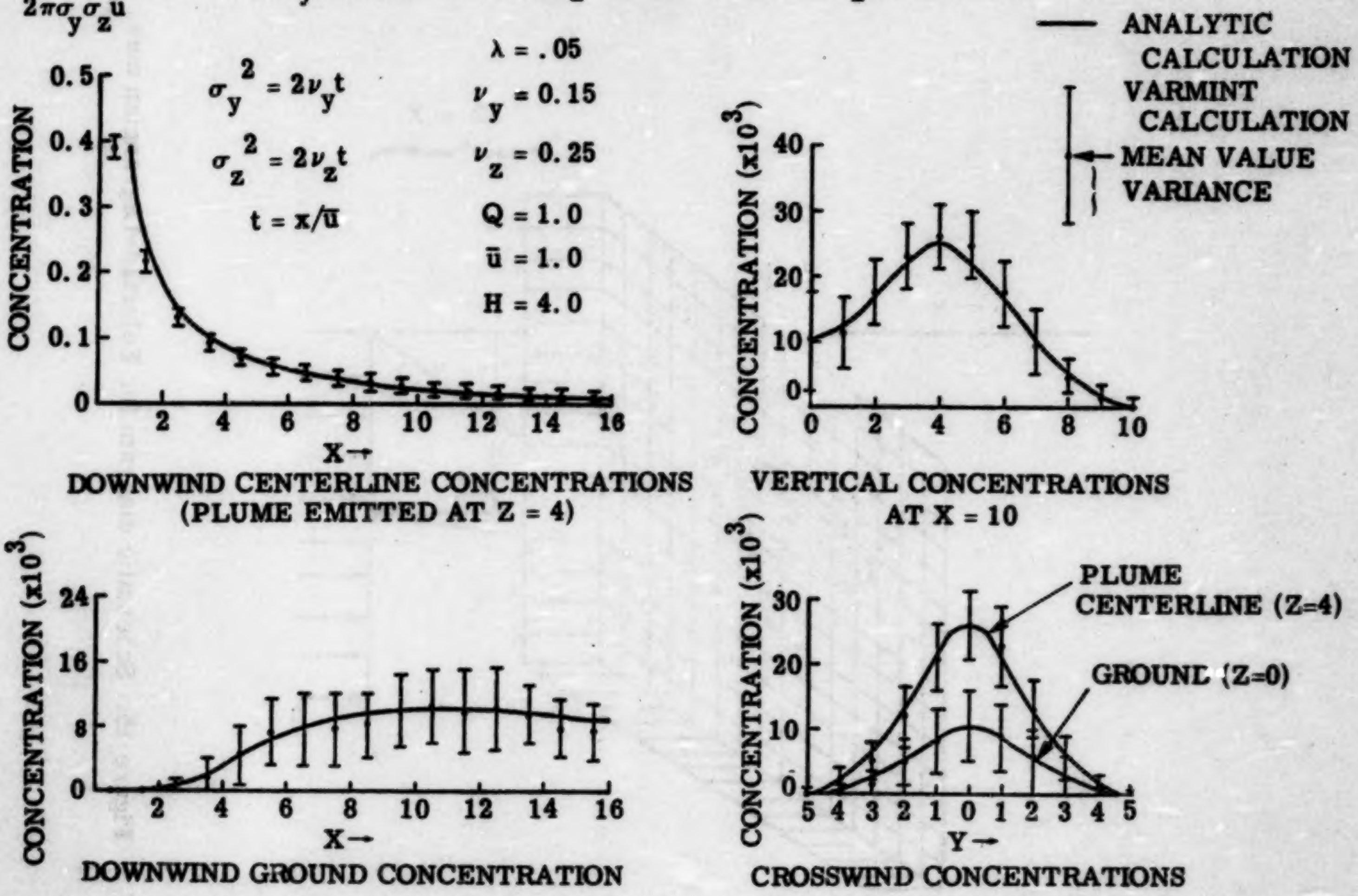


Figure 14. Comparison of VARMINT Calculation and Analytic Solution for a Point Source with Exponential Decay

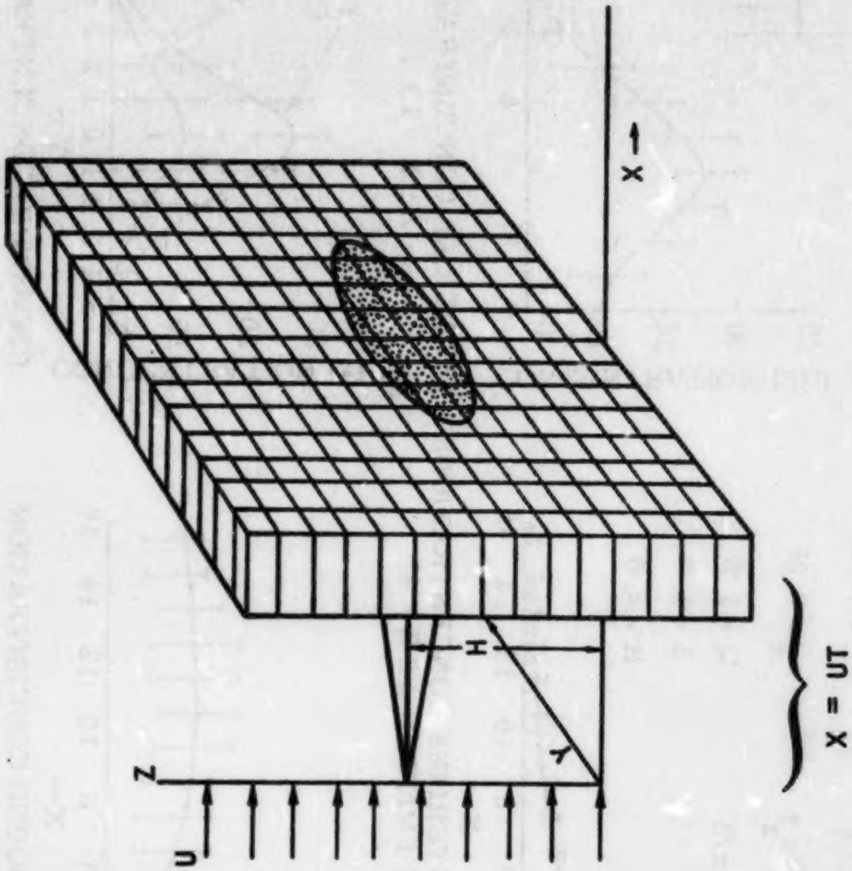
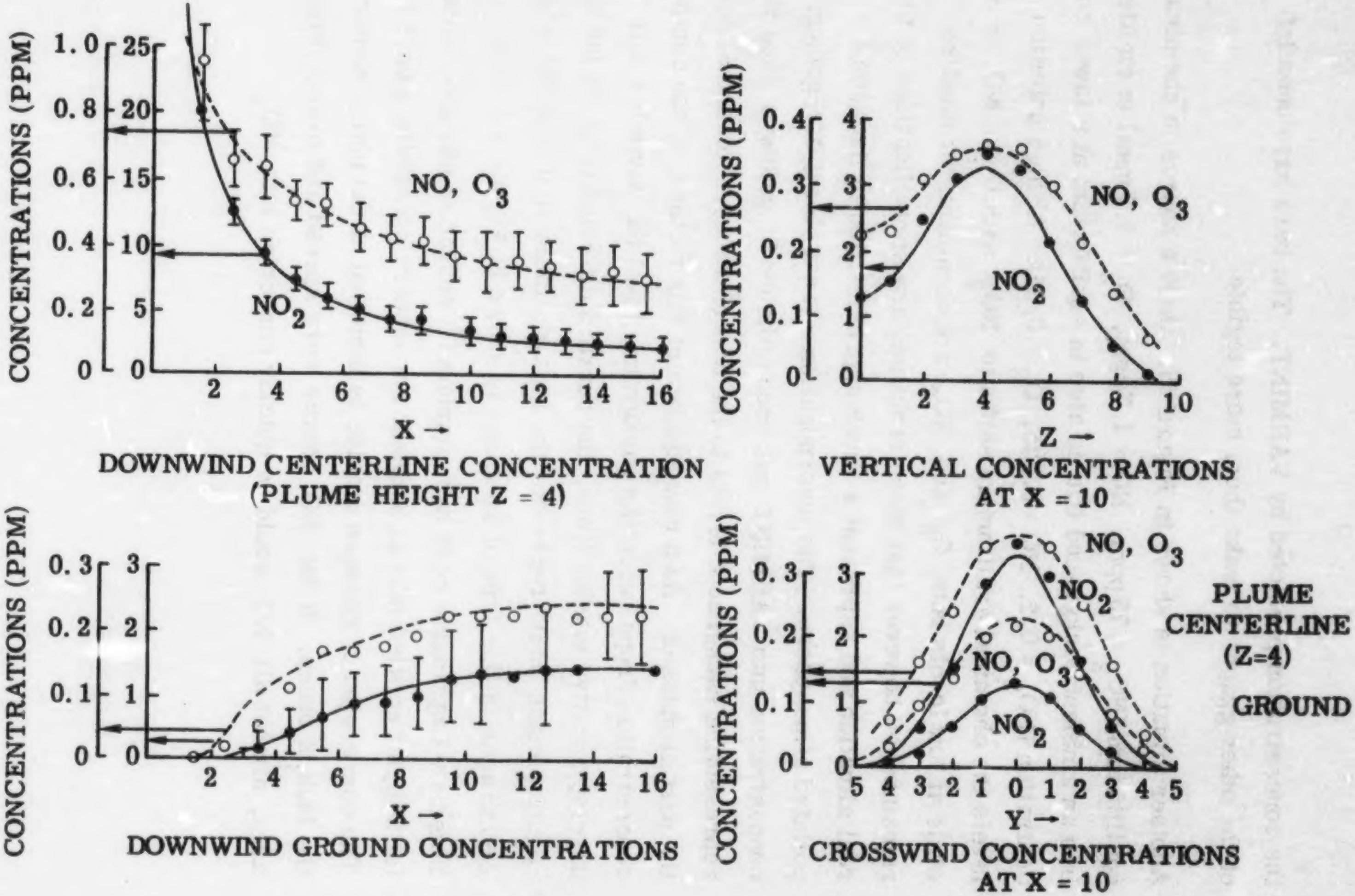


Figure 15. Schematic diagram for Eulerian-Lagrangian code.

the concentration predicted by VARMINT. The bars have been left off of the other graphs to make them more legible.

Another situation is shown in Figure 17. Here a source in chemical equilibrium (NO_2 = 73 ppm, NO = 1.7 ppm, O_3 = 1.7 ppm) is emitted into an ambient background that is also in equilibrium at a lower concentration (NO_2 = 0.2, NO = 0.035, O_3 = 0.24). At high pollution levels the chemical equilibrium shifts to NO_2 with little NO or O_3 while at low levels both O_3 and NO_2 are dominant. It must be remembered however that these reactions are simplifications of the real situation and represent a rough approximation to the actual polluted atmosphere. The incorporation of an ambient background concentration into VARMINT was accomplished by adding a fixed value representing background levels to the concentrations computed from the partial masses. As a consequence of this method, if the computed concentration drops below the background level the particles will develop negative mass. Thus, the outward diffusion of particles with negative mass would represent the inward diffusion of ambient pollutants. An example of this type of situation is shown in Figure 18. The Eulerian-Lagrangian code has simulated a source of nitrogen oxide (at 99 ppm) emitted into an ambient atmosphere containing ½ ppm ozone. The conversion of nitrogen dioxide is inhibited at the plume center by the lack of ozone. If the NO source were spread and over a large area, almost all NO would be quickly converted into NO_2.

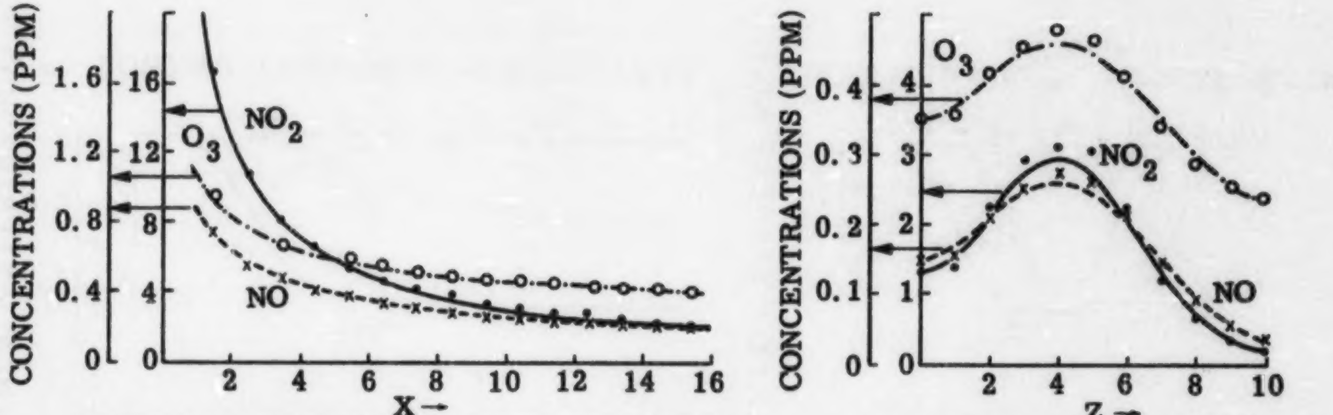

DOWNWIND CENTERLINE CONCENTRATION (PLUME HEIGHT Z = 4)

VERTICAL CONCENTRATIONS AT X = 10

DOWNWIND GROUND CONCENTRATIONS

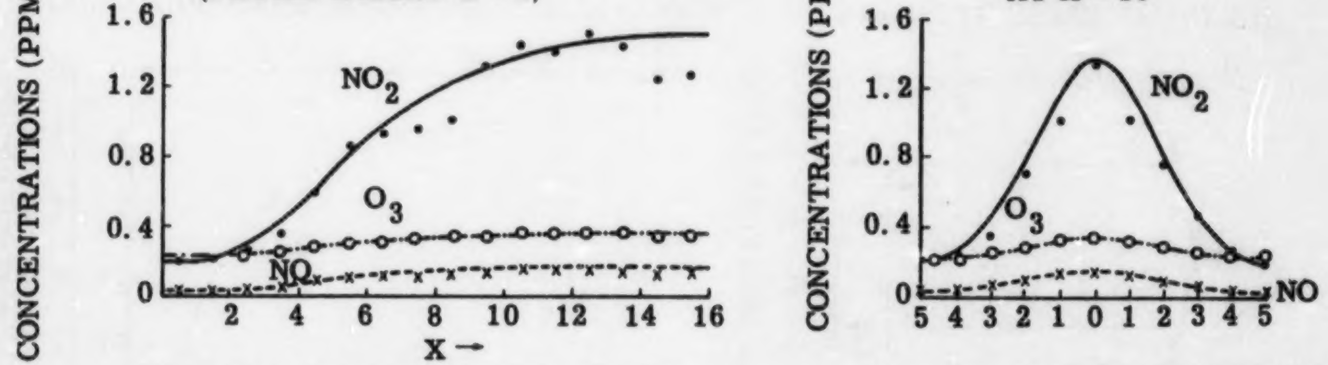
CROSSWIND CONCENTRATIONS AT X = 10

Figure 16. Nitrogen Dioxide Source Emitted into Clean Air



DOWNWIND CENTERLINE CONCENTRATIONS
(PLUME HEIGHT Z = 4)

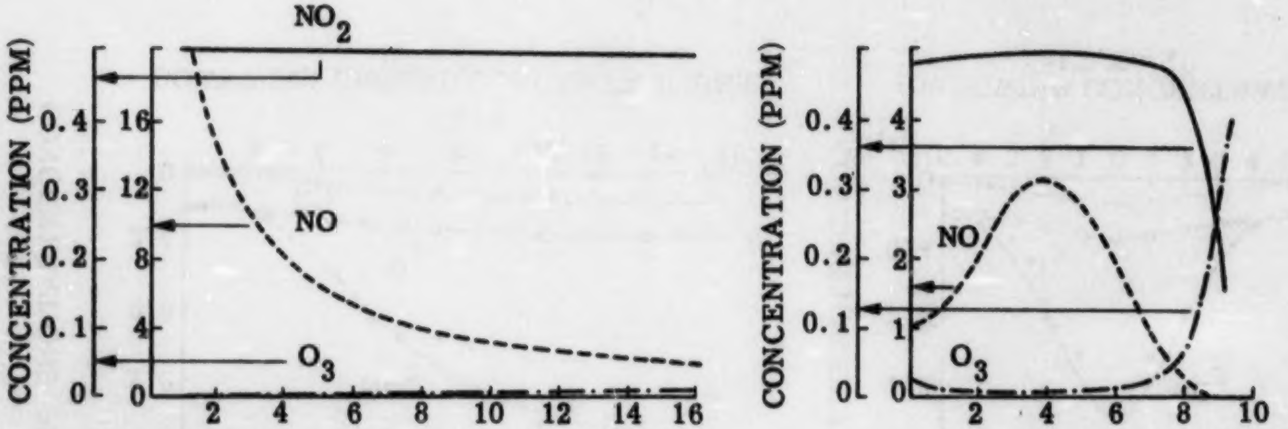
VERTICAL CONCENTRATIONS
AT X = 10



DOWNWIND GROUND CONCENTRATIONS

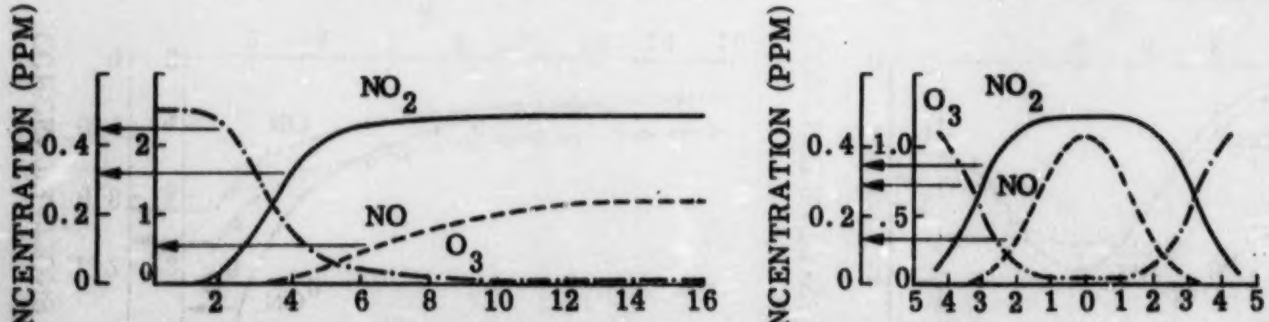
CROSSWIND CONCENTRATIONS
AT X = 10

Figure 17. Equilibrium Source Emitted into Equilibrium Ambient Background



DOWNWIND CENTERLINE CONCENTRATIONS (PLUME EMITTED AT Z=4)

VERTICAL CONCENTRATION AT X=10



DOWNWIND GROUND CONCENTRATIONS

CROSSWIND GROUND CONCENTRATION AT X=10

Figure 18. Nitrogen Oxide Source Emitted Into Ozone Background

SECTION VIII

REFERENCES

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5. Hotchkiss, R. S. and Hirt, C. W., Proceeding Summer Computer Simulation Conference, San Diego, California (June 1972).

SECTION IX

APPENDICES

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B. VARMINT Listing 73

A. USERS GUIDE FOR THE VARMINT CODE

The VARMINT code has been written for and run on the CDC 7600, using FORTRAN IV. The main program (VRC) is the driver program. There are eight subroutines, seven of which are standard, with the eighth (KEM) being an offshoot of the particle movement section and not accessing information by means of COMMON storage. This chemistry subroutine will differ for types of species and kinds of reactions desired. The subroutines are:

VRS - setup subroutines for calculational arrays,
FILMCO - sets film constants,
FLMCAL - calls IGSB plotting routines,
VRM - main calculations,
VRPS - particle movement,
KEM - chemistry,
VRIO - output section for printing and plotting,
VRTAP - tape handling.

The logic flow for these is shown in Figure 1.

A job will normally operate with external hardware for storage as well as I/O. Besides the card reader and line printer, it can require large core memory (LARGE statement), microfiche (TAPE9 for data, TAPE10 for plotting), and magnetic tapes (TAPE7 for tape dump writes, TAPE8 for tape dump reads). Small core memory houses the common blocks:

VRCOM	contains the array A equivalenced to the flow field parameters, plotting parameters, and cell volumes;
CONCEN	contains chemical concentration related arrays;
AMIX	contains a temporary array;

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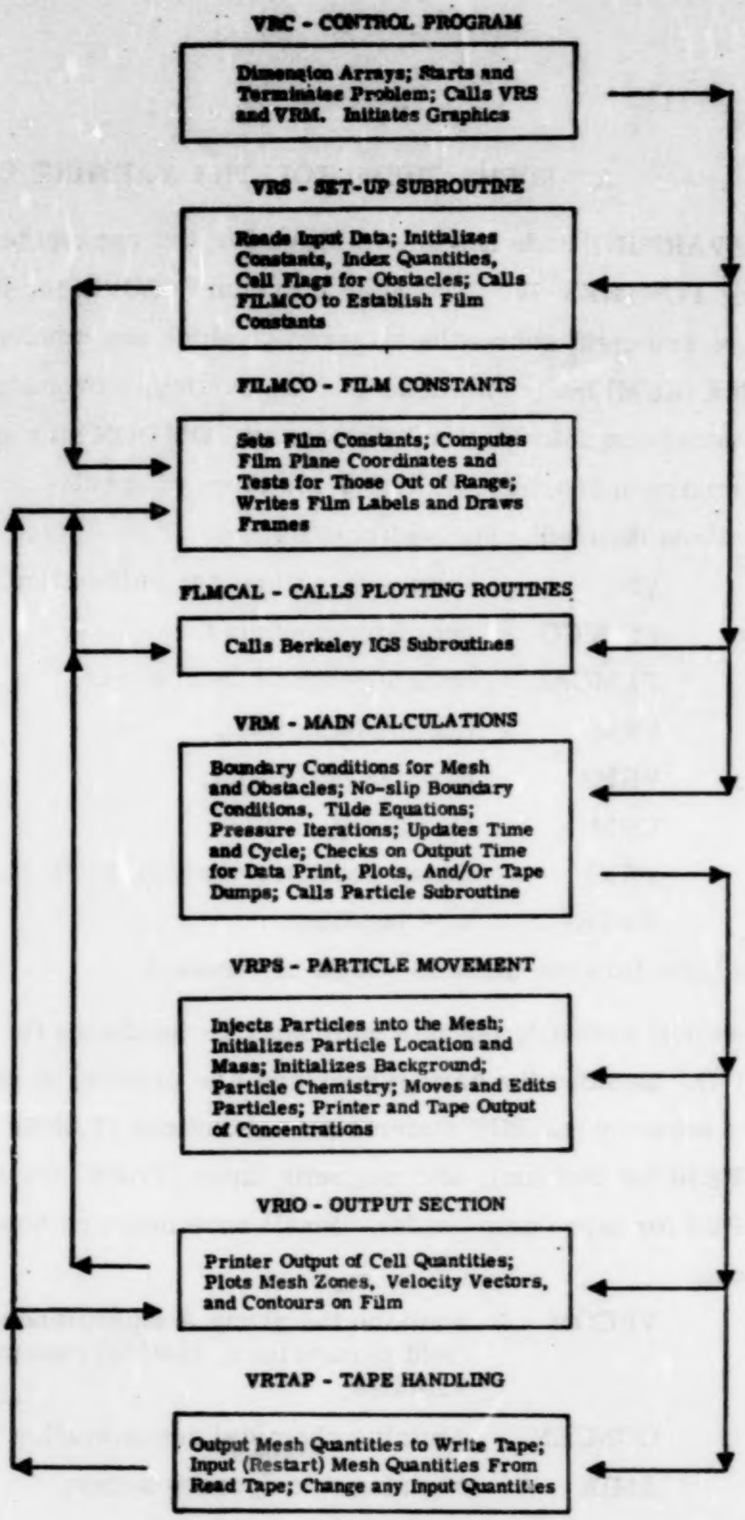

VRC - CONTROL PROGRAM
Dimension Arrays; Starts and Terminates Problem; Calls VRS and VRM. Initiates Graphics
VRS - SET-UP SUBROUTINE
Reads Input Data; Initializes Constants, Index Quantities, Cell Flags for Obstacles; Calls FILMCO to Establish Film Constants
FILMCO - FILM CONSTANTS
Sets Film Constants; Computes Film Plane Coordinates and Tests for Those Out of Range; Writes Film Labels and Draws Frames
FLMCAL - CALLS PLOTTING ROUTINES
Calls Berkeley IGS Subroutines
VRM - MAIN CALCULATIONS
Boundary Conditions for Mesh and Obstacles; No-slip Boundary Conditions, Tilde Equations; Pressure Iterations; Updates Time and Cycle; Checks on Output Time for Data Print, Plots, And/Or Tape Dumps; Calls Particle Subroutine
VRPS - PARTICLE MOVEMENT
Injects Particles into the Mesh; Initializes Particle Location and Mass; Initializes Background; Particle Chemistry; Moves and Edits Particles; Printer and Tape Output of Concentrations
VRIO - OUTPUT SECTION
Printer Output of Cell Quantities; Plots Mesh Zones, Velocity Vectors, and Contours on Film
VRTAP - TAPE HANDLING
Output Mesh Quantities to Write Tape; Input (Restart) Mesh Quantities From Read Tape; Change any Input Quantities

Figure 1. VARMINT flow chart.

FL	contains masking variables;
FLS	contains masking array;
VRCON	contains VARMINT constants;
MODSET	contains IGS film constants;
SAFLM	contains VARMINT generated film constants;
ZLAST	contains a dummy variable ZLAS which must always be the last variable in the last common block. The buffer length for tape dumps is calculated from the number of words between and including A(1) and ZLAS.

VARMINT INPUT DEFINITIONS

Rather than presetting all its constants within the code, VARMINT reads most of the non-calculated constants from cards. For each problem, the first two cards are read from VRC:

IBR - number of computational cells in x direction, if negative → stop, if 0 → restart;
JBR - number of computational cells in y direction;
KBR - number of computational cells in z direction, if IBR = 0 → KBR = tape dump number for restart;
PRFLM - film flag determines whether or not graphics are requested
0 → no film
1 → yes

LABEL: problem title.

VRS reads in the next cards:

DXC - size of cell in x direction
DYC - size of cell in y direction
DZC - size of cell in z direction
GX - body force in x direction
GY - body force in y direction
GZ - body force in z direction

ALX - donor or cell centered in x direction
ALY - donor or cell centered in y direction
ALZ - donor or cell centered in z direction
  0 → cell centered
  1 → donor

KWR - boundary condition flag for right wall
KWL - boundary condition flag for left wall
KWF - boundary condition flag for front wall
KWA - boundary condition flag for aft wall
KWT - boundary condition flag for top wall
KWB - boundary condition flag for bottom wall
  1 → rigid
  2 → continuative
  3 → periodic
B0 - relaxation factor
CEP - convergence criterion for pressure iteration

DT - time step

$$\delta t \le \frac{1}{4}\,\frac{\text{cell size}_{(\text{min})}}{\text{velocity}_{(\text{max})}}$$

TPLT - time increment between plots
TPRT - time increment between long prints
TFIN - time when to finish
TWTD - time when to dump on tape
NPRT - initial print options
  0 → no first print
  1 → print cycle 0
  2 → print cycle 0, 1 and at time TPRT

NGOP - number of graphics options (5 are available)
NOVP - number of variables to be plotted by the contours option
LPR - long print option
  1 → no long print
  2 → long print on microfiche
  3 → long print on paper
DROU - scaling factor for velocity vector plots

NWPC - number of words per cell equivalenced to A_{ijk}
NWPP - number of words per particle
    - particle coordinates and mass
NTPE - particle type
    1 → marker particles
    2 → turbulent particles

GPX - body force on particles, x direction
GPY - body force on particles, y direction
GPZ - body force on particles, z direction
NPMX - maximum particles allowed
UI - initial u velocity
VI - initial v velocity
WI - initial w velocity

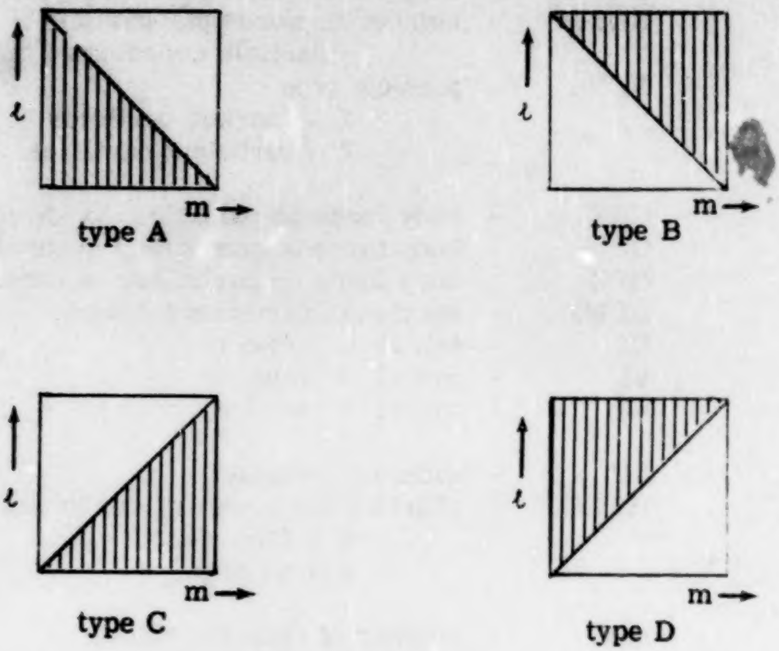
NU - diffusion constant
ISFLG - slip flag for boundary conditions
    0 → free slip
    1 → no slip

NRC - number of obstacle blocks

IL - left-most boundary cell of block
IR - right-most boundary cell of block
JA - aft-most boundary cell of block
JF - front-most boundary cell of block
KB - bottom-most boundary cell of block
KT - top-most boundary cell of block
OB - type of obstacle
    0 → cube
    1-12 → diagonal blocks (see Figure 2)

IF NGOP≠0,
$IGOP_i$ - graphics options
    1 → particles
    2 → zones
    3 → velocity vectors
    4 → contours
    5 → finish (this must be an included option)

For Cube: code = 0


ℓ
m
type A
ℓ
m
type B
ℓ
m
type C
ℓ
m
type D

For Diagonals:

code	1	2	3	4	5	6	7	8	9	10	11	12
type	A	C	A	C	D	B	D	B	A	D	C	B
ℓ-axis	K	K	K	K	K	K	K	K	J	J	J	J
m-axis	I	I	J	J	I	I	J	J	I	I	I	I

I: horizontal
J: fore-aft
K: vertical

Figure 2. Obstacle axis code.

IF NOVP≠0,

$VNTP_i$ - contour options
1 → pressure
2 → u velocity
3 → w velocity
4 → v velocity

$NCVTP_i$ - number of contours per contour plot

IPMM - number of cuts in I for J × K plane (vectors and contours)

IPM_m - locations of cuts (i.e., I cell no.)

JPPM - number of cuts in J for J × K plane

JPM_m - locations of cuts (i.e., J cell no.)

KPMM - number of cuts in K for I × J plane

KPM_m - location of cuts (i.e., K cell no.)

IPPP - particle plot projection for I plane

JPPP - particle plot projection for J plane

KPPP - particle plot projection for K plane
0 → not this plane
1 → this plane

IPROJ - perspective view plotting flag (not used at present so = 0)
0 → no perspective
1 → use perspective

The particle subroutine reads in the rest:

IPL - left (if IPL = 0, skip particle calculation)
IPR - right
JPA - aft
JPF - front
KPT - top
KPB - bottom
(IPL through KPB: side of particle source block cell number)
XPCEN - x coordinate for particle point source location
YPCEN - y coordinate for particle point source location
ZPCEN - z coordinate for particle point source location (if XPCEN = 0, particle will be placed at random inside source block above)
NOPI - number of particles to input

PDX - size of cell in x direction for particle mesh
PDY - size of cell in y direction for particle mesh
PDZ - size of cell in z direction for particle mesh
(PDX through PDZ: not used at present)
TWIP - time when to input particles
UPI - particle velocity in x direction
VPI - particle velocity in y direction
WPI - particle velocity in z direction
SIGMA - diffusivity

VARMINT is constructed for 3-dimensional simulation. For efficiency however, all arrays are singly dimensioned variables. For each time cycle, progression through the mesh is ordered by columns (K), next by rows (I), and finally by planes (J). The number of words per cell is essential for correct machine locations of the flow field variables operated on in each cell, for all positioning is done with indexing counters.

VRC is the control program of VARMINT. In VRC the problem date and time are called and printed before the input and output files are declared. The main array dimensions are read in along with the film option flag for plotting. The error flag is initialized; and if the film plot option is on, the graphics are initiated.

An array dimension determines the next logic sequence. If $\bar{I}$ is negative, the problem terminates; if $\bar{I}$ equals zero, restart procedures are instigated; if $\bar{I}$ is greater than zero, the value is assumed to be the size of the real mesh in the $\bar{I}$, or horizontal direction, and the problem is initialized.

When the problem is started by this last method, the problem label is the second data card read in. VRC then calls VRS to set up the problem. After VRS returns control, VRC calls VRM, which is the main calculational subroutine. If the problem were to be restarted, using the second method described above, VRC would call VRM immediately, bypassing VRS because the values therein would have been stored on magnetic tape which was generated during a previous run.

Following the calls to VRM and VRS the program checks the status of the error flag. If this had been tripped within one of the subroutines, graphics is concluded (when the plot flag is on), and the run is terminated with a printed diagnostic. Otherwise, we return to the beginning of the program and anticipate another problem. Hence, to end this run, the next data card must contain the negative $\bar{I}$. This negative $\bar{I}$ sends us to the section which concludes the graphics. We then exit, and the run terminates.

VRS sets up a specific problem for us. It reads the following from data cards:

- **The cell size constants for three dimensions,**
- **The prescribed body accelerations for 3 dimensions,**
- **The constants determining amount by which flux is calculated by donor or cell centered method for 3 dimensions,**
- **The boundary condition flags for the 6 walls:**
  1 → rigid
  2 → continuative
  3 → periodic,
- The relaxation factor for pressure iteration,
- The convergence criterion for pressure iterations,
- The time criteria,
- The diffusion constant,
- The obstacle no-slip flag, and
- The print options.

Then these input variables are printed.

VRS initializes constants and calculates cell index quantities. It checks for programming errors such as array dimensions exceeded. Whenever errors are found, the error flag is tripped and control returns to the calling program.

Next, VRS reads the obstacle limit cards and defines the obstacles in the mesh. Obstacle surface flags are set for no-slip boundary conditions. It reads and writes both graph options and contour plot values which are needed by VRIO. Graphic quantities are read in subsequently. Fluid flow arrays are initialized to zero. Velocities and cell sizes are initialized to prescribe input values. This section allows for variable zoning. Mesh coordinates are initialized. Cell volumes are calculated with allowances with respect to the obstacles. Plotting constants are set next with a call to FILMCO. Following this call, control is returned to VRC.

VRM is the main calculational subroutine. This is where the flow field is established and from which I/O and particle input are controlled.

First, VRM initializes PMAX for the pressure iteration and defines loop constants to be used in cell prints from VRIO. This section is never returned to during the course of this problem.

The calculational sequence for every time step begins at statement number 1000. Machine time for the cycle is noted and the pressure iteration counter is set to zero. A time dependent flag determines whether or not the hydro will be skipped; this flag allows passage on initial cycle. If the flag is tripped, we bypass the wind field calculations and decide whether or not to call the particle movement subroutine VRPS. This subroutine is only called when the maximum number of particles allowed in the system is greater than zero.

When the hydro is not to be bypassed, $\bar{I}$ must next be interpreted. If $\bar{I}$ equals zero, we jump to the final section of VRM where VRTAP, the tape I/O subroutine, is called. Hence, we are restarting a previously run problem. We read the dump tape until we arrive at the time T from which we wish to proceed. The information from the tape dump supplies all the parameters normally initialized in the set up subroutine VRS as well as the state of the flow field at time T. This data has been stored in the labeled common blocks VRCOM, CONCEN, AMIX, FL, FLS, VRCON, MODSET, SAFLM and ZLAST and are accessed by all subroutines and VRC. We return from VRTAP to statement number 1000 and continue with $\bar{I}$ now containing the integer number of computational cells in the x(or i) direction.

When $\bar{I}$ is greater than zero, it is assumed that we also have the number of computational cells in the y direction $(\bar{J})$ and the z direction $(\bar{K})$. First, the boundary conditions are set for the right and left walls, top and bottom walls, and then the fore and aft walls of the mesh. For each of the above, assigned GO TO statements route the user to the rigid, continuative, or periodic boundary conditions. No slip boundary conditions can also be calculated for these when the proper flag is set. Next, the free slip cbstacle boundary conditions are set, conditions depending on the obstacle type. Following this, the no-slip boundary conditions for obstacles are calculated, but only if the flag is set and the pressure iteration is not in progress.

Once boundary conditions have been set, we are free to calculate the tilde velocities. First, face No. 1 ($j = 1$ plane) and the left column and bottom row of velocity components for computational cells are transferred to storage arrays. Cell quantity indices are calculated along with diffusion. The u-, v-, and w-tilde fluxes for each cell are then calculated. Where

$$\tilde{u}_{i+\frac{1}{2}jk} = u_{i+\frac{1}{2}jk} + \frac{2\Delta t}{(\Delta x_i+\Delta x_{i+1})}(P_{ijk}-P_{i+1jk})+\Delta t g_x$$

$$+ \frac{\Delta t}{(\Delta x_i+\Delta x_{i+1})}[u_{i+1jk}(u_{i+\frac{1}{2}jk}+u_{i+\frac{3}{2}jk}) + \alpha_x|u_{i+1jk}|(u_{i+\frac{1}{2}jk}-u_{i+\frac{3}{2}jk})$$

$$- u_{ijk}(u_{i-\frac{1}{2}jk}+u_{i+\frac{1}{2}jk}) - \alpha_x|u_{ijk}|(u_{i-\frac{1}{2}jk}-u_{i+\frac{1}{2}jk})]$$

$$+ \frac{\Delta t}{2\Delta y_j}[v_{i+\frac{1}{2}j+\frac{1}{2}k}(u_{i+\frac{1}{2}jk}+u_{i+\frac{1}{2}j+1k}) + \alpha_y|v_{i+\frac{1}{2}j+\frac{1}{2}k}|(u_{i+\frac{1}{2}jk}-u_{i+\frac{1}{2}j+1k})$$

$$- v_{i+\frac{1}{2}j-\frac{1}{2}k}(u_{i+\frac{1}{2}j-1k}+u_{i+\frac{1}{2}jk}) - \alpha_y|v_{i+\frac{1}{2}j-\frac{1}{2}k}|(u_{i+\frac{1}{2}j-1k}-u_{i+\frac{1}{2}jk})]$$

$$+ \frac{\Delta t}{2\Delta z_k}[w_{i+\frac{1}{2}jk+\frac{1}{2}}(u_{i+\frac{1}{2}jk}+u_{i+\frac{1}{2}jk+1}) -\alpha_z|w_{i+\frac{1}{2}jk-\frac{1}{2}}(u_{i+\frac{1}{2}jk}+u_{i+\frac{1}{2}jk+1})$$

$$- w_{i+\frac{1}{2}jk-\frac{1}{2}}(u_{i+\frac{1}{2}jk-1}+u_{i+\frac{1}{2}jk}) - \alpha_z|w_{i+\frac{1}{2}jk-\frac{1}{2}}|(u_{i+\frac{1}{2}jk-1}-u_{i+\frac{1}{2}jk})]$$

$$+\frac{2}{(\Delta x_i+\Delta x_{i+1})}[(u_{i+\frac{3}{2}jk}-u_{i+\frac{1}{2}jk})\sigma_{i+1jk}/\Delta x_{i+1} - (u_{i+\frac{1}{2}jk}-u_{i-\frac{1}{2}jk})\sigma_{ijk}/\Delta_{xi}]$$

$$+\frac{2}{(\Delta y_j+\Delta y_{j+1})}[(u_{i+\frac{1}{2}j+1k}-u_{i+\frac{1}{2}jk})\sigma_{ij+1k}/\Delta y_{j+1}-(u_{i+\frac{1}{2}jk}-u_{i+\frac{1}{2}j-1k})\sigma_{ijk}/\Delta y_j]$$

$$+\frac{2}{(\Delta z_k+\Delta z_{k+1})}[(u_{i+\frac{1}{2}jk+1}-u_{i+\frac{1}{2}jk})\sigma_{ijk+1}/\Delta z_{k+1}-(u_{i+\frac{1}{2}jk}-u_{i+\frac{1}{2}jk-1})\sigma_{ijk}/\Delta z_k]$$

$$
\begin{aligned}
\tilde{v}_{ij+\frac{1}{2}k} = {} & v_{ij+\frac{1}{2}k} + \frac{2\Delta t}{(\Delta y_j+\Delta y_{j+1})}(P_{ijk}-P_{ij+1k})+\Delta t g_y \\
& + \frac{\Delta t}{2\Delta x_i}\left[u_{i+\frac{1}{2}j+\frac{1}{2}k}(v_{i+1j+\frac{1}{2}k}+v_{ij+\frac{1}{2}k}) + \alpha_x |u_{i+\frac{1}{2}j+\frac{1}{2}k}|(v_{i+1j+\frac{1}{2}k}-v_{ij+\frac{1}{2}k})\right. \\
& \left. - u_{i-\frac{1}{2}j+\frac{1}{2}k}(v_{i-1j+\frac{1}{2}k}+v_{ij+\frac{1}{2}k}) - \alpha_x |u_{i-\frac{1}{2}j+\frac{1}{2}k}|(v_{i-1j+\frac{1}{2}k}-v_{ij+\frac{1}{2}k})\right] \\
& + \frac{\Delta t}{(\Delta y_j+\Delta y_{j+1})}\left[v_{ij+1k}(v_{ij+\frac{1}{2}k}+v_{ij+\frac{3}{2}k}) + \alpha_y |v_{ij+1k}|(v_{ij+\frac{1}{2}k}-v_{ij+\frac{3}{2}k})\right. \\
& \left. - v_{ijk}(v_{ij-\frac{1}{2}k}+v_{ij+\frac{1}{2}k}) - \alpha_y |v_{ijk}|(v_{ij-\frac{1}{2}k}-v_{ij+\frac{1}{2}k})\right] \\
& + \frac{\Delta t}{2\Delta z_k}\left[w_{ij+\frac{1}{2}k+\frac{1}{2}}(v_{ij+\frac{1}{2}k}+v_{ij+\frac{1}{2}k+1}) + \alpha_z |w_{ij+\frac{1}{2}k+\frac{1}{2}}|(v_{ij+\frac{1}{2}k}-v_{ij+\frac{1}{2}k+1})\right. \\
& \left. - w_{ij+\frac{1}{2}k-\frac{1}{2}}(v_{ij+\frac{1}{2}k-1}+v_{ij+\frac{1}{2}k}) - \alpha_z |w_{ij+\frac{1}{2}k-\frac{1}{2}}|(v_{ij+\frac{1}{2}k-1}+v_{ij+\frac{1}{2}k})\right] \\
& + \frac{2}{(\Delta x_i+\Delta x_{i+1})}\left[(v_{i+1j+\frac{1}{2}k}-v_{ij+\frac{1}{2}k})\sigma_{i+1jk}/\Delta x_{i+1}-(v_{ij+\frac{1}{2}k}-v_{i-1j+\frac{1}{2}k})\sigma_{ijk}/\Delta x_i\right] \\
& + \frac{2}{(\Delta y_j+\Delta y_{j+1})}\left[(v_{ij+\frac{3}{2}k}-v_{ij+\frac{1}{2}k})\sigma_{ij+1k}/\Delta y_{j+1}-(v_{ij+\frac{1}{2}k}-v_{ij-\frac{1}{2}k})\sigma_{ijk}/\Delta y_j\right] \\
& + \frac{2}{(\Delta z_k+\Delta z_{k+1})}\left[(v_{ij+\frac{1}{2}k+1}-v_{ij+\frac{1}{2}k})\sigma_{ijk+1}/\Delta z_{k+1}-(v_{ij+\frac{1}{2}k}-v_{ij+\frac{1}{2}k-1})\sigma_{ijk}/\Delta z_k\right]
\end{aligned}
$$

$$
\begin{aligned}
\tilde{w}_{ij+\frac{1}{2}} = {} & w_{ijk+\frac{1}{2}} + \frac{2\Delta t}{(\Delta z_k+\Delta z_{k+1})}(P_{ijk}-P_{ijk+1}) + \Delta t g_z \\
& + \frac{\Delta t}{2\Delta x_i}\Big[u_{i+\frac{1}{2}j+\frac{1}{2}k}(w_{ij+\frac{1}{2}k}+w_{i+1j+\frac{1}{2}k}) \\
& + \alpha_x|u_{i+\frac{1}{2}j+\frac{1}{2}k}|(w_{ij+\frac{1}{2}k}-w_{i+1j+\frac{1}{2}k}) - u_{i-\frac{1}{2}j+\frac{1}{2}k}(w_{i-1j+\frac{1}{2}k}+w_{ij+\frac{1}{2}k}) \\
& - \alpha_x|u_{i-\frac{1}{2}j+\frac{1}{2}k}|(w_{i-1j+\frac{1}{2}k}-w_{ij+\frac{1}{2}k})\Big] \\
& + \frac{\Delta t}{2\Delta y_j}\Big[v_{ij+\frac{1}{2}k+\frac{1}{2}}(w_{ijk+\frac{1}{2}}+w_{ij+1k+\frac{1}{2}}) + \alpha_y|v_{ij+\frac{1}{2}k+\frac{1}{2}}|(w_{ijk+\frac{1}{2}}-w_{ij+1k+\frac{1}{2}}) \\
& - v_{ij-\frac{1}{2}k+\frac{1}{2}}(w_{ij-1k+\frac{1}{2}}+w_{ijk+\frac{1}{2}}) - \alpha_y|v_{ij-\frac{1}{2}k+\frac{1}{2}}|(w_{ij-1k+\frac{1}{2}}-w_{ijk+\frac{1}{2}})\Big] \\
& + \frac{\Delta t}{(\Delta z_k+\Delta z_{k+1})}\Big[w_{ijk+1}(w_{ijk+\frac{1}{2}}+w_{ijk+\frac{3}{2}}) + \alpha_z|w_{ijk+1}|(w_{ijk+\frac{1}{2}}-w_{ijk+\frac{3}{2}}) \\
& - w_{ijk}(w_{ijk-\frac{1}{2}}+w_{ijk+\frac{1}{2}}) - \alpha_z|w_{ijk}|(w_{ijk-\frac{1}{2}}-w_{ijk+\frac{1}{2}})\Big] \\
& + \frac{2}{(\Delta x_i+\Delta x_{i+1})}\Big[(w_{i+1jk+\frac{1}{2}}-w_{ijk+\frac{1}{2}})\sigma_{i+1jk}/\Delta x_{i+1}-(w_{ijk+\frac{1}{2}}-w_{i-1jk+\frac{1}{2}})\sigma_{ijk}/\Delta x_i\Big] \\
& + \frac{2}{(\Delta y_j+\Delta y_{j+1})}\Big[(w_{ij+1k+\frac{1}{2}}-w_{ijk+\frac{1}{2}})\sigma_{ij+1k}/\Delta y_{j+1}-(w_{ijk+\frac{1}{2}}-w_{ij-1k+\frac{1}{2}})\sigma_{ijk}/\Delta y_j\Big] \\
& + \frac{2}{(\Delta z_k+\Delta z_{k+1})}\Big[(w_{ijk+\frac{3}{2}}-w_{ijk+\frac{1}{2}})\sigma_{ijk+1}/\Delta z_{k+1}-(w_{ijk+\frac{1}{2}}-w_{ijk-\frac{1}{2}})\sigma_{ijk}/\Delta z_k\Big]
\end{aligned}
$$

These equations combine donor cell and cell-centered difference schemes; $\alpha = 1$ giving full donor cell, $\alpha = 0$ yielding centered differencing, a fraction in between promoting a combination thereof. Quantities needed at positions other than when they are defined are calculated as simple averages. The donor cell method is suggested for most cases because of the greater stability in the calculations without an additional viscous term. The diffusivity constant, σ, is an input quantity read from data cards in VRS or from the dump tape in VRTAP.

The tilde velocities must now be modified to insure conservation of mass. This is done in the pressure iteration section after boundary conditions have again been set. The velocity divergence D is calculated, and then the pressure is changed by an amount

$$\delta P = -\beta D$$

where

$$\frac{1}{\beta} = \frac{1}{\beta_o}\frac{\delta D_{ijk}}{\delta P_{ijk}} = \frac{1}{\beta_o}\left[\frac{1}{\Delta x_i}\frac{2\Delta t}{(\Delta x_i + \Delta x_{i+1})} + \frac{1}{\Delta x_i}\frac{2\Delta t}{(\Delta x_i + \Delta x_{i-1})}\right.$$

$$+ \frac{1}{\Delta y_j}\frac{2\Delta t}{(\Delta y_j + \Delta y_{j+1})} + \frac{1}{y_j}\frac{2\Delta t}{(\Delta y_j + \Delta y_{j-1})} + \frac{1}{\Delta z_k}\frac{2\Delta t}{(\Delta z_k + \Delta z_{k+1})}$$

$$\left. + \frac{1}{\Delta z_k}\frac{2\Delta t}{(\Delta z_k + \Delta z_{k-1})}\right] ,$$

and β_o is the relaxation factor. The velocities are then adjusted by adding the δP at the cell faces to the corresponding velocity component. This process is repeated successively in all cells until no cell has a magnitude of D greater than ϵ, where ϵ is a function of the magnitude of the velocities calculated.

When the pressures converge within 1000 iterations, the time counter is updated by dt and VRM calls for cell prints in VRIO. These will not necessarily be printed every cycle but rather at a predetermined time interval TPRT.

The boundary conditions are reset. If particles are to be allowed in the field, the particle movement subroutine VRPS is called. At appropriate time intervals, the particles will move within the wind field. This calling section is the first section of operation for the time cycle when the hydro is bypassed. When the hydro has been skipped, the timer is not updated, so the time is updated here under these circumstances.

The subroutine FILMCO contains entry points under which various film constants are computed or tested. Also, the film frame is appropriately labeled. A call to FILMCO checks that film option is on, sets mesh length reciprocals, sets film coordinate starting points, and initializes do loop constants. Entry at FPLAN computes film plane coordinates and constants for the I × K, I × J or J × K plane. Entry at FCTEST performs a test to determine whether film coordinates are out of range and resets those which are. Entry at FLMID labels SAI, date, time and cycle and draws the frame.

The subroutine FLMCAL contains the calls to the Berkeley SC 4060 graphic routines. Entry FLMADV records the display and advances the film. Entry FLMFIN terminates the graphic output. Entry FLMINIT initializes the graphics package. Entry FLMLAB labels the film frame. Entry FLMLIN draws noncontiguous line segments. Entry FLMPNT plots points. Entry FLMOPT computes graphics options such as redefining the plot point, character size, line width and density, and point size.

The particle subroutine VRPS is responsible for the injection of particles into the mesh; for initializing particle location and mass, for initializing background, for particle chemistry (through calls to KEM), for moving and editing the particles, and for printer and tape output of particle information.

VRPS is called by the main calculations subroutine VRM when the maximum number of particles allowed in the mesh (NPMX, an input parameter) is greater than zero. The first pass through VRPS invokes the read statements which initialize particle input locations and specify point or area assignments, time when to input particles, particle velocities in x, y, and z directions, the number of particles to input per pass, and the diffusivity. Background and concentration constants are set, as well as the probability curves used in the turbulent dispersion section. If the time to input particles is greater than the time of the initial call to VRPS, control is returned to VRM.

At the appropriate time interval, particles are emitted by one of two methods: assignments to a point or an area. When the input variable specifying the x-coordinate of the point location (XPCEN) is less than or equal to zero, the area source is calculated from a given left, aft, and bottom local boundary and a fraction of the corresponding upper bounds, the fraction being determined by a random number generator. When XPCEN is greater than zero, a point source location is designated using the coordinates given in the input variables (XPCEN, YPCEN, ZPCEN). The particle locations for both cases are stored in the dimensional variables XPC, YPC, and ZPC. Up to ten species, or chemicals, are allotted to each particle location. Each has an initial mass which is assigned to the variable PM, PM increasing by the number of species. The number of particles emitted each time is the same for each species and has been assigned by the constant NOPI.

The first time that particles are emitted, masses and locations are assigned, and then control is returned to VRM. Thereafter, entries to VRPS bypass the initializing sequence and preassign the logic flow for the marker particles and the turbulent dispersion equations. The concentration array is zeroed out, if that option is on, and then begins the major loop for the calculation of particle transport.

The location of each particle composite (or block), a composite containing N species, is arrived at by taking the integer part of the location variable. This tells us which cell the block is in. To find out how far into the cell the block has progressed, we use the decimal part of the same variable. Using the velocity components of the flow field for this and adjacent cells, we interpolate the u, v, and w fluid velocities for simple marker particle advection in the following manner:

define $IX1 = IX + \mathrm{sgn}(XW - .5)*1.0$, $XW1 = XW - .5$

$IY1 = IY + \mathrm{sgn}(YL - .5)*1.0$, $YL1 = YL - .5$

$IZ1 = IZ + \mathrm{sgn}(ZH - .5)*1.0$, $ZH1 = ZH - .5$

where IX, IY, and IZ are the cell numbers in the x, y, and z directions, respectively, and XW, YL, and ZH are the corresponding fractions describing the distance the particle has moved within the cell.

I1, J1, and K1 are the resulting cell numbers described by IXI, IYI, and IZI, respectively.

The flux velocity components of the particle are:

$$\begin{aligned}
U_P = XW \{ & (1\text{-}YL1)\ [(ZH1)(U_{ijk1}) + (1\text{-}ZH1)(U_{ijk})] \\
& + (YL1)\ [(ZH1)(U_{ij|k1}) + (1\text{-}ZH1)(U_{ij1k})] \} \\
& + (1\text{-}XW) \{ (1\text{-}YL1)\ [(ZH1)(U_{i-1jk1} + (1\text{-}ZH1)(U_{i-1jk})] \\
& + (YL1)\ [(Zh1)(U_{i-1j|k1}) + (1\text{-}ZH1)(U_{i-1j|k})] \} \quad ;
\end{aligned}$$

$$\begin{aligned}
W_P = ZH \{ & (1\text{-}XW1)\ [YL1)(W_{ij|k}) + (1\text{-}YL1)(W_{ijk})] \\
& + (XW1)\ [(YL1)(W_{i|j|k}) + (1\text{-}YL1)(W_{i|jk})] \} \\
& + (1\text{-}ZH) \{ (1\text{-}XW1)\ [(YL1)(W_{ij|k-1}) + (1\text{-}YL1)(W_{ijk-1})] \\
& + (XW1)\ [(YL1)(W_{i|j|k-1}) + (1\text{-}YL1)(W_{i|jk-1})] \} \quad ;
\end{aligned}$$

$$\begin{aligned}
V_P = YL \{ & (1\text{-}ZH1)\ [(XW1)(V_{i|jk}) + (1\text{-}XW1)(V_{ijk}) \\
& + (XH1)\ [(XW1)(V_{i|jk1}) + (1\text{-}XW1)(V_{ijk1})] \} \\
& + (1\text{-}YL) \{ (1\text{-}ZH1)\ [(XW1)(V_{i|j-1k}) + (1\text{-}XW1)(V_{ij-1k})] \\
& + (ZH1)\ [(XW1)(V_{i|j-1k1}) + (1\text{-}XW1)(V_{ij-1k1})] \} \quad .
\end{aligned}$$

Second order particle advection can be calculated in like manner.

Another option available is turbulent dispersion. The displacement is added to the fluid velocity component and is defined as $\delta X = \sqrt{4\sigma\, dt}\ W \operatorname{sgn}(1-2\xi)$ where ξ is chosen randomly and satisfies the conditions

$$\xi = \frac{2}{\sqrt{\pi}} \int_0^W e^{-z^2}\, dz \quad , \quad 0 \le \xi \le 1 \quad ;$$

σ is the local diffusion coefficient;

dt is the time step;

$$W = W_k + \left(\frac{W_{k+1} - W_k}{R_{k+1} - R_k} \right) (\xi - R_k)$$ such that 20k-values are

are found for $W_k = \frac{W_{max}}{\#k}\, k$, $k=1$, ... , $\#k$ and W_{max} is an upper limit such that particles will seldom shift more than one cell. R_k are solutions for

$$R_k = \frac{2}{\sqrt{\pi}} \int_0^{W_k} e^{-z^2}\, dz \quad , \quad R_k \le \xi \le R_{k+1} \quad .$$

The particle is then moved and given its new location as

$$XW_{new} = XW_{old} + \frac{U_p\, dt}{\Delta X} \quad ,$$

$$YW_{new} = YW_{old} + \frac{V_p\, dt}{\Delta Y} \quad ,$$

$$ZW_{new} = ZW_{old} + \frac{W_p\, dt}{\Delta Z}$$

after a particle has been reflected off an obstacle or the ground if its new displacement would have put it there. When a new displacement places the particle outside of the mesh, its new location is not retained. It is considered as outside the area of interest.

New concentrations must now be calculated for each cell. The particle masses for each species are summed for the cell into which the particle block has entered. This process continues until all particles have been moved.

We then loop through all species and all mesh cells to calculate the molecular concentrations for each cell from particle mass, cell volume, molecular weight, ppm conversion factor, weight of air, and background. At the appropriate time interval, these concentrations are printed or written on tape.

Next, the cells alone are looped over and the chemistry subroutine KEM is called to prescribe the reactions of the N species and deliver a new concentration for each. Then, each particle is reweighted as a function of the ratio of old concentration to new concentration.

If the time is less than the next time when to input particles, then the time, cycle number, particle masses and locations, and the number of particles in the system are printed and control is returned to VRM. Otherwise, more particles, determined by the constant NOPI, are added to the system at the predetermined source location and mass is assigned to each one. Then the printing described above occurs and control is returned to VRM.

The current subroutine KEM solves the inorganic loop of the photochemical air pollution reactions

$$\begin{aligned} &1.\quad (h\nu) + NO_2 \xrightarrow{k_1} NO + O \\ &2.\quad O + (O_2) + (M) \xrightarrow{k_2} O_3 + (M) \qquad (1) \\ &3.\quad O_3 + NO \xrightarrow{k_3} NO_2 + (O_2) \end{aligned}$$

where $h\nu$ represents the ultraviolet photons of the solar flux, the third body, M, is the total concentration of all species present and the k's are the rate coefficients. The species in parens are assumed to remain constant and their values are incorporated into the rate constants. All concentrations are in parts per million (ppm). The values for k are estimated by Eschenneder to be

$$k_1 = 0.4 \text{ min}^{-1}$$

$$k_2 = 2.64 \times 10^6 \text{ min}^{-1}$$

$$k_3 = 30\text{-}40 \text{ ppm}^{-1} \text{ min}^{-1}$$

This set of reactions can be solved analytically as discussed below.

Noting that the value of k_2 is much greater than either k_1 or k_3, we can assume that the second reaction is in pseudo-equilibrium when compared to the other two reactions. Further, at equilibrium, we see that the ratio of O_3 to O is k_2 or that atomic oxygen, O, is about one millionth of the concentration of ozone, O_3.

Assuming that all oxygen is either O_2 or O_3 we can simplify Eq. (1) to

$$\begin{aligned} (O_2) + NO_2 &\xrightarrow{k_1} NO + O_3 \\ NO + O_3 &\xrightarrow{k_3} NO_2 + (O_2) \end{aligned} \qquad (2)$$

We further note that the total of all nitrogen, NO_X, and the total of all oxidents, TOX, remain constant, i.e.,

$$\begin{aligned} TOX &= NO_2 + O_3 = \text{constant} \\ NO_X &= NO_2 + NO = \text{constant} \end{aligned} \qquad (3)$$

This means that NO and O_3 can be expressed as functions of NO_2 and the constants TOX and NO_X

$$\begin{aligned} NO &= NO_X - NO_2 \\ O_3 &= TOX - NO_2 \end{aligned} \qquad (4)$$

We can, therefore, write the chemical rate equations in terms of only one species NO_2.

$$\frac{dNO_2}{dt} = - k_1 NO_2 + k_3 (NO)(O_3)$$

becomes

$$\frac{dNO_2}{dt} = - k_1 NO_2 + k_3(NO_X - NO_2)(TOX - NO_2) \quad . \tag{5}$$

Defining $y \equiv NO_2$ we can express Eq. (5) in the standard quadratic form

$$\frac{dy}{dt} = ay^2 + by + c \tag{6}$$

where

$$a = k_3$$

$$b = - k_1 - k_3 (TOX + NO_X)$$

$$c = k_3 \cdot NO_X \cdot TOX \quad .$$

If the rate of change of y (NO_2) is zero, the chemical reactions are in equilibrium and we can solve for the equilibrium value of y .

$$y_e = \frac{- b \pm \sqrt{b^2 - 4ac}}{2a}$$

Expanding the coefficients we find that the physically correct solution is

$$y_e = \frac{- b - \sqrt{b^2 - 4ac}}{2a} \quad . \tag{7}$$

If the time rate of change of y is not equal to zero we must solve the integral equation

$$\int_o^t dt = \int_{y_o}^{y} \frac{dy}{ay^2 + by + c} \quad . \tag{8}$$

The solution for the integral

$$\int \frac{dy}{ay^2 + by + c}$$

is given as

$$\begin{array}{ll} -\frac{2}{R} \tanh^{-1} \left(\frac{2ay + b}{R}\right) & b^2 > 4ac \\ & (2ay + b)^2 < b^2 - 4ac \\ -\frac{2}{R} \operatorname{ctnh}^{-1} \left(\frac{2ay + b}{R}\right) & b^2 > 4ac \\ & (2ay + b)^2 > b^2 - 4ac \\ -\frac{2}{2ay + b} & b^2 = 4ac \end{array} \qquad (9)$$

where

$$R = (b^2 - 4ac)^{\frac{1}{2}} \quad .$$

Solving equation (8) we get

$$t = -\frac{2}{R} f^{-1} \left(\frac{2ay + b}{R}\right) + C \qquad (10)$$

for $R \neq 0$, where f is either tanh or ctnh depending on the value of $(2ay + b)^2 - b^2 - 4ac$, and C is a constant of integration.

We can solve for C by noting at $t = 0$, $y = y_o$ so

$$C = \frac{2}{R} f^{-1} \left(\frac{2ay_o + b}{R}\right) \quad . \qquad (11)$$

Solving Eq. (10) for y gives

$$y = (-b + R \cdot f(-(t-C)R/2))/2a \qquad (12)$$

Note as $t \rightarrow \infty$, $f \rightarrow 1$, and $y \rightarrow y_e$ as $t \rightarrow 0$ $y = -b\, R \cdot f(cR/2)/2a$ and by Eq. (11) $y = y_o$.

Subroutine VRIO handles the printing and graphics output. The first section prints cell quantities and the second handles graphic output. Each can be executed without entering the domain of the other.

The first section encountered is the line printer section. After the subroutine is entered, if long print is not desired, if the hydro has been skipped, or if printing is not desired at this time of entry, then the printing section is skipped. Otherwise, VRIO sets up printer counters and flags and writes the time, cycle number, the number of iterations needed to converge during the pressure iteration, and the time increment dt. At cycle zero, the cell coordinates and cell sizes are displayed. Then and thereafter, the cell numbers and their respective pressures and velocity components are printed.

The graphic section is entered whether or not long print is required. Only the input flag for plotting being off can return control to the calling routine at this intermediate step. Otherwise, control is returned at the completion of the requested plots.

The graphic section can be separated into several parts, each part dealing with one of the available graphic options. After the options are initialized, the option counter is incremented, sending VRIO to either particle, mesh zone, velocity, vector, and/or contour plotting.

The first part plots particle coordinates, initializes constants necessary in plotting the particles, and then sets constants for either the I × K, the I × J, or the J × K plane. It is possible to obtain a view from each of these planes, but each view must be a separate plot. The mesh zone plot follows the same general set up for plane constants as the particle plot. It then draws line segments to display the mesh from any of the three planes. Zones, however, will only be plotted once; the first time VRIO is called for plotting purposes. The velocity vectors and the contours are viewed from a specific plane, or cut, within the mesh. This is unique in that, while particles and zones are viewed from only the front, top, or right of the mesh, looking across all of the cells, the cut limits the view to a 2-D case. The user designates his I × K, I × J, or J × K viewing plane and will receive plots of only the quantity within that plane.

The velocity vector plot follows the same pattern of setting up constants for vectors and film plane coordinates as the earlier parts. It uses the velocity vector components appropriate for the particular view plane in computing the coordinates between which it will draw a line segment proportional to the magnitude and in the direction of the velocity, neglecting the velocity component normal to the plane. It then plots the vector.

The contouring plot again initializes general constants to plot the contours on film. The number of contour lines is optional. It then sets loop constants for the I × K, I × J, or J × K planes and encodes the title and labels the film. It transfers the desired variable to a contour storage array and computes the maximum and minimum values of this variable. The contour loop flags each contour cell, sets coordinates for the desired plane, and checks the contour variable value in each cell with respect to neighboring cells. When contour demarcation values are within this neighborhood, the vertex position might need a shift. If so, it calculates volume constants, contour cell volume, and the shifted vertex position. It then plots the contour on film.

After each plot, VRIO can go to various exits. It will either set up for a new plane and plot the same quantity from a different view point, or it will return to the beginning of the plotting section to increment the plotting counter and, by means of a computed GO TO, go to another plotting part. The last plotting option must always be included (now equal to 5), because this directs logic flow to return to the calling routine.

VRTAP is called for magnetic tape manipulations. Upon entry, $\bar{I}$ is interogated. If it is not zero, VRTAP proceeds to write mag tape records of the buffer length, the common blocks starting from VRCOM down to ZLAST, and the particle array stored in large core memory. It prints the tape dump number, the program time, and the cycle number for the user's reference.

When $\bar{I}$ equals zero, the subroutine assumes a restart request. It rewinds the dump tape and reads records until it arrives at the tape dump number requested by the initial $\bar{K}$. It then prints the time, cycle, and tape dump number. After this point, the users may insert any desired changes to common stored information, such as time when to finish. It then calls FILMCO and VRIO before returning to the calling routine.

B. VARMINT LISTING

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```
 VRC
          PROGRAM VRC (INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT,TAPE10,       VARP.2
         1 TAPE7,TAPE8,TAPE9,TAPE13)                                      VE3.10
          LARGE PTP(30000),CON(15000)                                     VE3.11
          INTEGER F,ERF,VDI,VDU,BUFL,PYML,PXML,CPRT,VNTP,VTP,PF,TD,TD1,TD2, INREAL.2
         1 PRFLM,COF,SHIFT,OBLOC,OBTYP,FI,FO,FB,FM,OBTYPL                 INREAL.3
          REAL NU                                                         INREAL.4
    C                                                                     INREAL.5
          DIMENSION U(1),V(1),W(1),P(1),CQ(1),COF(1)                      DIMEN.2
         1 ,VOL(1)                                                        DIMEN.3
          DIMENSION SPEC(10),ISP(10)                                      VE3.1
          DIMENSION TA(1),QCON(1)                                         DIMEN.6
    C                                                                     DIMEN.7
          COMMON/VRCOM/A(36000)                                           VE3.2
          COMMON/CONCEN/ NSPS(10),PMAXWS(10),PMINWS(10),BKGS(10),FACS(10) VE3.3
         1 ,IPEDIT(10),IPEL(10),IPES(10),PMIN(10)                         VE3.4
          COMMON /AMIX/ C(600)                                            COMM.5
          COMMON/FL/FO(20),FB(8),FM                                       COMM.6
          COMMON/FLS/FI(9)                                                COMM.7
          COMMON/VRCON/ALX,ALY,ALZ,RO,BUFL,CEP,DT,DX(80),DXC,DY(80),DYC,  VE3.5
         1 DZ(80),DZC,EMO,EM6,ERF,GPX,GPY,GPZ,GX,GY,GZ,IBP1,IBP2,IBR,IBRED, VE3.6
         2 IBRIN,IBRST,IGOP(6),IJKMX,IJKNC,IJK2,IJP1K,IPL,IPR,ITER,I2JK2,  COMM.10
         * IKP2,IPARTF,IPLTF,ISFLG,RIBJBKB,LPR,DROU,                      COMM.11
         *IJKCON,ICON,JCON,                                               COMM.12
         3 I2K2,JBP1,JBP2,JBR,JBRED,JBRIN,JBRST,JNC,JPA,JPF,J2NC,KBP1,KBP2, COMM.13
         4 KBR,KBRED,KBRIN,KBRST,KFP,KNC,KPR,KPT,KWA,KWB,KWF,KWL,KWR,KWT, COMM.14
         5 K2NC,LABEL(8),LNPART,LNVRCM,LPARTC,NCIP,NCVIP(6),NCYC,NGOP,NOPI, COMM.15
         *NOCONC,                                                         COMM.16
         * OBLOC(1200),OBTYP(1200),NOB,NU,                                VE3.7
         6 NOVP,NOVS,NPRX,NPRT,NTPE,NWFC,NWPP,PDX,PDY,PDZ,PI,PRFLM,RDT,   COMM.18
         7 RDX(80),RDY(80),RDZ(80),RRAN(20),SIGMA,TD,TD1,TD2,TFIN,TIMET,TIP,VE3.8
         8 TPL,TPLT,TPR,TPRT,TTD,TWIP,TWID,UI,UPI,VDI,VDU,VI,VNTP(6),VPI,  COMM.20
         9 VTP,WI,WPI,WRAN(20),X(80),XPCEN,Y(80),YPCEN,Z(80),ZPCEN        VE3.9
          COMMON /MODSET/ SCFLM(200)                                      COMM.22
          COMMON /SAFLM/ XCONV,ZCONV,FX1,FX2,FX3,FX4,FY1,FY2,FY3,FY4,     COMM.23
         1 FXL,FYB,PXL,PYB,IFLB(3),FFX3(75),FFY3(75)                      COMM.24
         2 ,ITCYC(3),XFC1(4),XFC2(4),YFC1(4),YFC2(4),PBTIM(2),XML,YML,ZML COMM.25
         3 ,IFMID,IFTEST,IPLOPT,IPM(20),IPMM,IPPP,IPROJ,JPM(20),JPMM,JPPP, COMM.26
         4 KPM(20),KPMM,KPPP,NEC,NMC,NPS,NPV,PEC(10),PMC(10),YCONV        COMM.27
         5 ,IFLAB,IFLIN,IFPNT,IFOPT,NCH,XFSP,XT,YFSP,YT                   COMM.28
          COMMON /ZLAST/ ZLAS                                             COMM.29
    C                                                                     COMM.30
          EQUIVALENCE (A(1),U),(A(2),V),(A(3),W),(A(4),P),(A(5),CQ),      EQUIV.2
         1 (A(6),COF), (A(7),VOL)                                         EQUIV.3
          EQUIVALENCE (C(1),TA,QCON)                                      EQUIV.7
    C                                                                     EQUIV.8
        1 FORMAT(1H1)                                                     VARP.8
        2 FORMAT(8A10)                                                    VARP.9
        3 FORMAT(3(5X,I5),5X,I2)                                          VARP.10
        4 FORMAT(1H ,4X,4HIBR=,I5/5X,4HJBR=,I5/5X,4HKBR=,I5/3X,6HPRFLM=,I2) VARP.11
        5 FORMAT(1H ,57H **** NEGATIVE IBR READ IN WHICH TERMINATES PROGRAM VARP.12
         1*****)                                                          VARP.13
        6 FORMAT(1H ,21H THE PROBLEM DATE IS ,A10,5X,21H THE PROBLEM TIME ISVARP.14
         1 ,A10)                                                          VARP.15
      100 CALL SECOND(S1)                                                 VARP.16
    4     CALL DATE(XT)                                                   VARP.17
    6     PATIM(1)=XT                                                     VARP.18
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VRC
      10          CALL HOUR(XT)                                                   VARP.19
      11          PBTIM(2)=XT                                                     VARP.20
      12          VDI=5                                                           VARP.21
      13          VDO=6                                                           VARP.22
      15          WRITE(VDO,1)                                                    VARP.23
      20          READ(VDI,3) IBR,JBR,KBR,PRFLM                                   VARP.24
      34          WRITE(VDO,4) IBR,JBR,KBR,PRFLM                                  VARP.25
      50          WRITE(VDO,6) PBTIM(1),PBTIM(2)                                  VARP.26
      62      200 ERF=0                                                           VARP.27
      63          IF( PRFLM.GT.0 ) CALL FLMINIT                                   VARP.28
      66      300 IF(IBR) 600,500,400                                             VARP.29
      70      100 READ(VDI,2) LABEL                                               VARP.30
      76          WRITE(VDO,2) LABEL                                              VARP.31
     104      420 CALL VHS                                                        VARP.32
     105          IF( ERF.EQ.1 ) GO TO 700                                        VARP.33
     107      500 CALL VHM                                                        VARP.34
     110          IF( ERF.EQ.1 ) GO TO 700                                        VARP.35
     112          GO TO 100                                                       VARP.36
     113      600 WRITE(VDO,5)                                                    VARP.37
     117      700 IF( PRFLM.GT.0 ) CALL FLMFIN                                    VARP.38
     122          CALL EXIT                                                       VARP.39
     123          END                                                             VARP.40


PROGRAM LENGTH INCLUDING I/O BUFFERS

04045

FUNCTION ASSIGNMENTS

STATEMENT ASSIGNMENTS
1       - 000143    2       - 000145    3       - 000147    4       - 000152    5       - 000162    6       - 000172
100     - 000003    200     - 000063    300     - 000067    400     - 000071    420     - 000105    500     - 000110
600     - 000114    700     - 000120

BLOCK NAMES AND LENGTHS
  *LCM*= 0127710
VRCOM   - 106240/01 CONCEN  - 000132/02 AMIX    - 001130/03 FL      - 000035/04 FLB     - 000011/05 VRCON   - 006352/06
MODSET  - 000310/07 SAFLM   - 000497/08 ZLAST   - 000001/11

VARIABLE ASSIGNMENTS
A       - 000000/01 BKGS    - 000036/02 BUFL    - 000004/06 C       - 000000/03 CON     - 0072460/LC CPRJ   - 000207
CQ      - 000004/01 CQF     - 000005/01 DX      - 000007/06 DY      - 000130/06 DZ      - 000251/06 EHF     - 000374/06
F       - 000204    FACS    - 000050/02 FB      - 000024/04 FFX3    - 000021/08 FFY3    - 000134/08 FI      - 000000/05
FM      - 000034/04 FO      - 000000/04 IBR     - 000405/06 IFLB    - 000016/08 IGOP    - 000411/06 IPEDII  - 000062/02
IPEL    - 000074/02 IPES    - 000106/02 IPM     - 000302/08 IICYC   - 000247/08 JBR     - 000444/06 JPM     - 000351/08
KBR     - 000456/06 KPM     - 000357/08 LABEL   - 000475/06 NCVIP   - 000511/06 NSPS    - 000000/02 NU      - 005264/06
OBLOC   - 000525/06 OBTYP   - 003003/06 OBTYPL  - 000212    P       - 000003/01 PBTIM   - 000272/08 PEC     - 000411/08
PF      - 000210    PMAXWS  - 000012/02 PMC     - 000423/08 PMIN    - 000120/02 PMINWS  - 000024/02 PRFLM   - 005300/06
PTM     - 0000000/LC PXML   - 000206    PYML    - 000205    QCON    - 000000/03 RDX     - 005302/06 RDY     - 005422/06
RDZ     - 005542/06 RHAN    - 005662/06 SCFLM   - 000000/07 SHIFT   - 000211    SPEC    - 000213    S1      - 000237
TA      - 000000/03 TD      - 005707/06 TD1     - 005710/06 TD2     - 005711/06 TSP     - 000225    U       - 000000/01
V       - 000001/01 VDI     - 005726/06 VDO     - 005727/06 VNTP    - 005731/06 VOL     - 000006/01 VIP     - 005740/06
W       - 000002/01 WRAN    - 005743/06 X       - 005767/06 XFC1    - 000252/08 XFC2    - 000256/08 XT      - 000444/08
Y       - 006110/06 YFC1    - 000262/08 YFC2    - 000266/08 Z       - 006231/06
```

```
      SUBROUTINE VRB                                                    VARP.41
      LARGE PIM(30000), CON(15000)                                      VF3.12
      INTEGER F,EHF,VDI,VDO,BUFL,PYML,PXML,CPRT,VNTP,VIP,PF,TD,TD1,TD2, INREAL.2
     1 PHFLM,COE,SHIFT,OBLOC,OBTYP,FI,FO,FB,FM,OBTYPL                   INREAL.3
      REAL NU                                                           INREAL.4
C                                                                       INREAL.5
      DIMENSION U(1),V(1),W(1),P(1),CO(1),COF(1)                        DIMEN.2
     1 ,VOL(1)                                                          DIMEN.3
      DIMENSION SPEC(10),TSP(10)                                        VF3.1
      DIMENSION TA(1),QCON(1)                                           DIMEN.6
C                                                                       DIMEN.7
      COMMON/VRCOM/A(36000)                                             VE3.2
      COMMON/CONCEN/ NSPS(10),PMAXWS(10),PMINWS(10),BKGS(10),FACS(10)   VE3.3
     1 ,IPEDIT(10),IPEL(10),IPES(10),PMIN(10)                           VE3.4
      COMMON /AMIX/ C(600)                                              COMM.5
      COMMON/FL/FO(20),FB(8),FM                                         COMM.6
      COMMON/FLS/FI(9)                                                  COMM.7
      COMMON/VRCON/ALX,ALY,ALZ,BO,BUFL,CEP,DT,DX(80),DXC,DY(80),DYC,    VE3.5
     1 DZ(80),DZC,EMO,EM6,ERF,GPX,GPY,GPZ,GX,GY,GZ,IBP1,IBP2,IBR,IBRED, VE3.6
     2 IBRIN,IBRST,IGUP(6),IJKMY,IJKNC,IJK2,IJP1K,IPL,IPH,ITER,I2JK2,   COMM.10
     * IKP2,IPARTF,IPLTF,ISFLG,RIBJAKB,LPR,DROU,                        COMM.11
     *IJKCON,ICON,JCON,                                                 COMM.12
     3 I2K2,JBP1,JBP2,JBR,JBRED,JBRIN,JBRST,JNC,JPA,JPF,J2NC,KBP1,KBP2, COMM.13
     4 KBR,KBRED,KBRIN,KBRST,KFP,KNC,KPB,KPT,KWA,KWB,KWF,KWL,KWR,KWT,   COMM.14
     5 K2NC,LABEL(8),LNPART,LNVRCM,LPARTC,NCTP,NCVTP(6),NCYC,NGUP,NOPI, COMM.15
     *NOCONC,                                                           COMM.16
     * OBLOC(1200),OBTYP(1200),NUM,NU,                                  VE3.7
     6 NOVP,NOVS,NPMX,NPRT,NTPF,NWPC,NWPP,PDX,PDY,PDZ,PI,PHFLM,ROT,     COMM.18
     7 RDX(80),RDY(80),RDZ(80),RRAN(20),SIGMA,TD,TD1,TD2,TFIN,TIMET,TIP,VE3.8
     8 TPL,TPLT,TPR,TPRT,TTD,TWIP,TWTD,UI,UPI,VDI,VDO,VI,VNTP(6),VPI,   COMM.20
     9 VTP,WI,WPI,WRAN(20),X(80),XPCEN,Y(80),YPCEN,Z(80),ZPCEN          VE3.9
      COMMON /MODSET/ SCFLM(200)                                        COMM.22
      COMMON /SAFLU/ XCONV,ZCONV,FX1,FX2,FX3,FX4,FY1,FY2,FY3,FY4,       COMM.23
     1 FXL,FYB,PXL,PYB,IFLB(3),FFX3(75),FFY3(75)                        COMM.24
     2 ,ITCYC(3),XFC1(4),XFC2(4),YFC1(4),YFC2(4),PBTIM(2),XML,YML,ZML   COMM.25
     3 ,IFMID,IFIEST,IPLOPT,IPM(20),IPMM,IPPP,IPROJ,JPM(20),JPMM,JPPP,  COMM.26
     4 KPM(20),KPMM,KPPP,NEC,NMC,NPS,NPV,PEC(10),PMC(10),YCONV          COMM.27
     5 ,IFLAB,IFLIN,IFPNT,IFOPT,NCH,XFSP,XT,YFSP,YT                     COMM.28
      COMMON /ZLAST/ ZLAS                                               COMM.29
C                                                                       COMM.30
      EQUIVALENCE (A(1),U),(A(2),V),(A(3),W),(A(4),P),(A(5),CO),        EQUIV.2
     1 (A(6),COF), (A(7),VOL)                                           EQUIV.3
      EQUIVALENCE (C(1),TA,QCON)                                        EQUIV.7
C                                                                       EQUIV.8
    1 FORMAT(1H ,47H *** ENTERED SUBROUTINE VRB - SETUP PROGRAM ***)    VARP.47
    2 FORMAT(9(F8.3))                                                   VARP.48
    3 FORMAT(6(I2),2(F8.3))                                             VARP.49
    4 FORMAT(1H ,44H *** ERROR 001 - MESH DIMENSION EXCEEDED ***)       VARP.50
    5 FORMAT(6X,6(I2))                                                  VARP.51
    6 FORMAT(1H ,6H NGUP ,6(2X,I2))                                     VARP.52
    7 FORMAT(3(5X,I2,1X,I3))                                            VARP.53
    8 FORMAT(1H ,75H *** ERROR 002 - ATTEMPTED TO READ IN MORE THAN 100 VARP.54
     1CONTOUR PLOT VALUES ***)                                          VARP.55
    9 FORMAT(1H ,6H VNTP=,I2,4X,7H NCVTP=,I3)                           VARP.56
   10 FORMAT(5(F8.3),I2)                                                VARP.57
   11 FORMAT(1H ,54H *** ERROR 005 - PARTICLE ARRAY DIMENSION EXCEEDED *VARP.58
```

VRB

```
            1*)                                                                 VARP.59
         12 FORMAT(3(I3),F8.3)                                                  VARP.60
         13 FORMAT(3(I3))                                                       VARP.61
         14 FORMAT(3(F8.3),I6,3(F8.3))                                          VARP.62
         15 FORMAT(1H ,71H *** ERROR 009 - NUMBER OF CONTOUR VARIABLES TO BE PVARP.63
           1LOTTED EXCEEDED ***)                                                VARP.64
         16 FORMAT(5X,I3,1X,20(I3))                                             VARP.65
         17 FORMAT(3X,I3,3X,I3,10(F6.2))                                        VARP.66
         18 FORMAT(3(5X,I3),6X,I2)                                              VARP.67
         20 FORMAT(1H ,* ---ERROR 010, OBSTACLE ARRAYS DIMENSION EXCEEDED*)     VARP.68
         21 FORMAT(1H ,2X,*NOB*,20X,*OBTYP*,5X,*OBLOC*,                         VARP.69
           1       5X,*I*,5X,*J*,5X,*K*,/)                                      VARP.70
         22 FORMAT(1H ,4X,* NREC=*,I6)                                          VARP.71
         23 FORMAT(1H ,4X,* IL= *,I3,* IR= *,I3,* JA= *,I3,* JF= *,I3,          VARP.72
           1                  * KB= *,I3,* KT= *,I3,* OB= *,F6.1)               VARP.73
         24 FORMAT(3X,I3,5X,O20,5X,I5,4X,I3,4X,I3,4X,I3)                        VARP.74
         25 FORMAT(F8.3,I2)                                                     VARP.75
         26 FORMAT(1H ,3X,4H NU=,F8.3/ 4X,7H ISFLG=,I2)                         VARP.76
         30 FORMAT(1H ,4X,4HDXC=,1PE12.5/5X,4HDYC=,E12.5/5X,4HDZC=,E12.5/       VARP.77
           1 6X,3HGX=,E12.5/6X,3HGY=,E12.5/6X,3HGZ=,E12.5/5X,4HALX=,E12.5/      VARP.78
           2 5X,4HALY=,E12.5/5X,4HALZ=,E12.5)                                   VARP.79
         31 FORMAT(1H ,4X,4HKWR=,I3/5X,4HKWL=,I3/5X,4HKWF=,I3/5X,4HKWA=,I3/     VARP.80
           1 5X,4HKWT=,I3/5X,4HKWB=,I3/6X,3HBO=,1PE12.5/5X,4HCEP=,E12.5)        VARP.81
         32 FORMAT(1H ,5X,3HDT=,1PE12.5/4X,5HTPLT=,E12.5/4X,5HTPRT=,E12.5/      VARP.82
           1 4X,5HTFIN=,E12.5/4X,5HTWTD=,E12.5/4X,5HNPRT=,I2)                   VARP.83
         33 FORMAT(1H ,3X,5HNGOP=,I3/4X,5HNOVP=,I3/5X,4HLPR=,I3/                VARP.84
           1 4X,5HDROU=,1PE12.5)                                                VARP.85
         34 FORMAT(1H ,3X,5HNWPC=,I3/4X,5HNWPP=,I3/4X,5HNTPE=,I3)               VARP.86
         35 FORMAT(1H ,4X,4HGPX=,1PE12.5/5X,4HGPY=,E12.5/5X,4HGPZ=,E12.5/       VARP.87
           1 4X,5HNPMX=,I6/6X,3HUI=,E12.5/6X,3HVI=,F12.5/6X,3HWI=,E12.5)        VARP.88
         36 FORMAT(1H ,6H IPPM ,I3,1X,20(I3))                                   VARP.89
         37 FORMAT(1H ,6H JPMM ,I3,1X,20(I3))                                   VARP.90
         38 FORMAT(1H ,6H KPMM ,I3,1X,20(I3))                                   VARP.91
         39 FORMAT(1H ,5H NPV ,I3,2X,5H NEC ,I3,10(2X,F6.2))                    VARP.92
         40 FORMAT(1H ,6H IPPP ,I3,2X,6H JPPP ,I3,2X,6H KPPP ,I3/3X,6HIPROJ=,   VARP.93
           1 I2)                                                                VARP.94
         41 FORMAT(1H ,5H NPV ,I3,2X,5H NMC ,I3,10(2X,F6.2))                    VARP.95
      C ***** THIS SECTION, 100 , READS AND PRINTS THE INPUT DATA               VARP.96
        100 WRITE(VDO,1)                                                        VARP.97
    5         READ(VDI,2)  DXC,DYC,DZC,GX,GY,GZ,ALX,ALY,ALZ                     VARP.98
   33         READ(VDI,3)   KWR,KWL,KWF,KWA,KWT,KWB,BO,CEP                      VARP.99
   57         READ(VDI,10)  DT,TPLT,TPRT,TFIN,TWTD,NPRT                         VARP.100
   77         READ(VDI,12)  NGOP,NOVP,LPR,DROU                                  VARP.101
  113         READ(VDI,13)  NWPC,NWPP,NTPE                                      VARP.102
  125         READ(VDI,14)  GPX,GPY,GPZ,NPMX,UI,VI,WI                           VARP.103
  147         READ(VDI,25)  NU,ISFLG                                            VARP.104
  157         WRITE(VDO,30) DXC,DYC,DZC,GX,GY,GZ,ALX,ALY,ALZ                    VARP.105
  205         WRITE(VDO,31) KWR,KWL,KWF,KWA,KWT,KWB,BO,CEP                      VARP.106
  231         WRITE(VDO,32) DT,TPLT,TPRT,TFIN,TWTD,NPRT                         VARP.107
  251         WRITE(VDO,33) NGOP,NOVP,LPR,DROU                                  VARP.108
  265         WRITE(VDO,34) NWPC,NWPP,NTPE                                      VARP.109
  277         WRITE(VDO,35) GPX,GPY,GPZ,NPMX,UI,VI,WI                           VARP.110
  321         WRITE(VDO,26) NU,ISFLG                                            VARP.111
      C ***** THIS SECTION, 120 , CALCULATES CONSTANTS                          VARP.112
  331   120 TIMET=0.0                                                           VARP.113
  332         TD=0                                                              VARP.114
```

```
 VRB
     332         NCYC=0                                                           VARP.115
     333         RDT=1./DT                                                        VARP.116
     335         PI=3.14159265                                                    VARP.117
     336         EM6=1.E-6                                                        VARP.118
     337         EM0=-EM6                                                         VARP.119
     340         TPL=TPLT                                                         VARP.120
     342         TPR=TPRT                                                         VARP.121
     343         ITD=IMID                                                         VARP.122
     345         FO(1)=0B                                                         VARP.123
     345         FO(2)=1B                                                         VARP.124
     347         FB(1)= 1000B                                                     VARP.125
     350         FB(2)= 100000B                                                   VARP.126
     352         FB(3)= 10000000B                                                 VARP.127
     353         FB(4)= 1000000000B                                               VARP.128
     355         FB(5)= 100000000000B                                             VARP.129
     356         FB(6)= 10000000000000B                                           VARP.130
     360         FB(7)= 1000000000000000B                                         VARP.131
     361         FP=777B                                                          VARP.132
           C ***** THIS SECTION , 124 , CALCULATES CELL INDEX QUANITIES            VARP.133
     363     124 IBP1=IBR+1                                                       VARP.134
     365         KBP1=KBR+1                                                       VARP.135
     366         IBP2=IBR+2                                                       VARP.136
     370         KBP2=KBR+2                                                       VARP.137
     370         I2K2=IBP2*KBP2*NWPC                                              VARP.138
     373         JBP1=JBR+1                                                       VARP.139
     375         JBP2=JBR+2                                                       VARP.140
     375         IJK2=IBP2*JBP2*KBP2                                              VARP.141
     400         IJKNC=IJK2*NWPC                                                  VARP.142
     402         IJKMX=IJKNC+I2K2                                                 VARP.143
     403         K2NC=KBP2*NWPC                                                   VARP.144
     405         IJP1K=I2K2*JBP1                                                  VARP.145
     407         I2JK2=I2K2*JBR                                                   VARP.146
     411         KNC=KBR*NWPC                                                     VARP.147
     413         JNC=JBR*NWPC                                                     VARP.148
     414         J2NC=JBP2*NWPC                                                   VARP.149
     416         IKP2=IBR*K2NC                                                    VARP.150
     421         I1K2=IBP1*KBP2*NWPC                                              VARP.151
     424         IM1K2=(IBR-1)*K2NC                                               VARP.152
     426         RIBJRKR=1./FLOAT( IBR*JBR*KBR )                                  VARP.153
           C ***** THIS SECTION, 125 , CHECKS FOR ARRAY DIMENSIONS EXCEED          VARP.154
     433         LNVRCM= LOCF(NSPS(1)) -LOCF(A) +1                                VE3.13
     441         LNPART= LOCF(C)- LOCF(NSPS(1))                                   VE3.14
     447     125 LPARTC= 30000                                                    VE3.15
           C   THIS IS THE SIZE OF LARGE CORE STORAGE TO CLEAR PTM                VE3.16
     450         BUFL=LOCF(ZLAB)-LOCF(A)+1                                        VARP.158
     456         IF( IJKMX.GT.LNVRCM ) GO TO 127                                  VARP.159
     462         GO TO 130                                                        VARP.161
           C ***** *** ERROR 001 - IBAR OR KBAR ARRAY DIMENSION EXCEEDED ***      VARP.162
     462     127 WRITE(VDO,4)                                                     VARP.163
     466         EMF=1                                                            VARP.164
     467         GO TO 99999                                                      VARP.165
           C *****  THIS SECTION, 130, INPUTS OBSTACLES                           VARP.170
     470     130 NOB=0                                                            VARP.171
     471         READ(VDI,12)  NREC                                               VARP.172
     477         WRITE(VDO,22)  NREC                                              VARP.173
     505         IF( NREC.LE.0 ) GO TO 135                                        VARP.174
```

```
VRS
 507              IF( NREC.GT.200) GO TO 134                                    VARP.175
          C *****  SET OBSTACLE ARRAYS                                          VARP.176
 512              DO 133  L=1,NREC                                              VARP.177
 513              READ(VDI,3)  IL,IR,JA,JF,KB,KT,OB                             VARP.178
 534              WRITE(VDU,23) IL,IR,JA,JF,KB,KT,OB                            VARP.179
 556              IOB=IFIX(OB)+1                                                VARP.180
 561              DO 132 I=IL,IR                                                VARP.181
 563              DO 132 J=JA,JF                                                VARP.182
 565              DO 132 K=KB,KT                                                VARP.183
 567              IOB=0                                                         VARP.184
 570              GO TO (1000,1010,1020,1030,1040,1050,1060,1070,1080,1090,     VARP.185
                1       1100,1110,1120) ,  IOB                                  VARP.186
 611       1010 IF (( KT-K) - (I-IL) ) 132,1200,1000                            VARP.187
 616       1020 IF (( I-IL) - (K-KB) ) 132,1200,1000                            VARP.188
 623       1030 IF (( KT-K) - (J-JA) ) 132,1200,1000                            VARP.189
 630       1040 IF (( J-JA) - (K-KB) ) 132,1200,1000                            VARP.190
 635       1050 IF (( K-KB) - (I-IL) ) 132,1200,1000                            VARP.191
 642       1060 IF (( I-IL) - (KT-K) ) 132,1200,1000                            VARP.192
 647       1070 IF (( K-KB) - (J-JA) ) 132,1200,1000                            VARP.193
 654       1080 IF (( J-JA) - (KT-K) ) 132,1200,1000                            VARP.194
 661       1090 IF (( JF-J) - (I-IL) ) 132,1200,1000                            VARP.195
 666       1100 IF (( J-JA) - (I-IL) ) 132,1200,1000                            VARP.196
 673       1110 IF (( I-IL) - (J-JA) ) 132,1200,1000                            VARP.197
 700       1120 IF (( I-IL) - (JF-J) ) 132,1200,1000                            VARP.198
 705       1200  IOB=IFIX(OB)                                                   VARP.199
 707       1000  NOB=NOB+1                                                      VARP.200
          C *****  CHECK FOR OBSTACLE ARRAYS EXCEEDED                           VARP.201
 711              IF(NOB.GT.1200) GO TO 134                                     VF3.17
 714              IJK= (I-1)*K2NC + (J-1)*I2K2 + (K-1)*NWPC + 1                 VARP.203
 727              OBLOC(NOB)=IJK                                                VARP.204
 730              OBTYP(NOB)=IOB                                                VARP.205
 732         132 CONTINUE                                                       VARP.206
 742         133 CONTINUE                                                       VARP.207
          C ****  SET OBSTACLE SURFACE FLAG FOR NO SLIP B.C.                    VARP.208
 744              DO 1335 L=1,NOB                                               VARP.209
 747              IJK= OBLOC(L)                                                 VARP.210
 750              KT= FB(1) * FO(2)                                             VARP.211
 752              IR= FB(2) * FO(2)                                             VARP.212
 755              IL= FB(3) * FO(2)                                             VARP.213
 757              JA= FB(4) * FO(2)                                             VARP.214
 762              JF= FB(5) * FO(2)                                             VARP.215
 764              KB= FB(6) * FO(2)                                             VARP.216
 767              IJKM= IJK-NWPC                                                VARP.217
 770              IJKP= IJK+NWPC                                                VARP.218
 771              IJMK= IJK-I2K2                                                VARP.219
 773              IJPK= IJK+I2K2                                                VARP.220
 773              IMJK= IJK-K2NC                                                VARP.221
 775              IPJK= IJK+K2NC                                                VARP.222
 776              DO 1330 LL=1,NOB                                              VARP.223
 777              IJKL= OBLOC(LL)                                               VARP.224
1000              IF( IJKL.EQ.IJK) GO TO 1330                                   VARP.225
1002              IF(IJKL.EQ.IJKM) KB= FB(6)*FO(1)                              VARP.226
1006              IF(IJKL.EQ.IJKP) KT= FB(1)*FO(1)                              VARP.227
1013              IF(IJKL.EQ.IJMK) JA= FB(4)*FO(1)                              VARP.228
1017              IF(IJKL.EQ.IJPK) JF= FB(5)*FO(1)                              VARP.229
1023              IF(IJKL.EQ.IMJK) IL= FB(3)*FO(1)                              VARP.230
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VRS
   1027          IF(IJKL.EQ.IPJK) IR= FB(2)*FD(1)                                    VARP.231
   1033    1330 CONTINUE                                                             VE3.18
   1037          IJK= IJK-1                                                          VARP.232
   1040          JJ= 1+ IJK/I2K2                                                     VARP.233
   1043          II= 1+ (IJK- (I2K2*(JJ-1))) /K2NC                                   VARP.234
   1051          KK= 1+ (IJK-(K2NC* (II-1))- (I2K2*(JJ-1)))/ NWPC                    VARP.235
   1062          IF( II.EQ.2) IL= FB(3)* FD(1)                                       VARP.236
   1067          IF( II.EQ. IBP1) IR= FB(2)* FD(1)                                   VARP.237
   1073          IF( JJ.EQ.2) JA= FB(4)* FD(1)                                       VARP.238
   1077          IF( JJ.EQ.JBP1) JF= FB(5)* FD(1)                                    VARP.239
   1103          IF( KK.EQ.2) KB= FB(6)* FD(1)                                       VARP.240
   1110          IF( KK.EQ.KMP1) KT= FB(1)* FD(1)                                    VARP.241
   1114          OBTYP(L)= ((((( OBTYP(L).OR.KT) .OR.IR) .OR.IL) .OR.JA) .OR.JF)     VARP.243
               1 .OR.KB                                                              VARP.244
   1122    1335 CONTINUE                                                             VARP.245
         C ***** *** ERROR 010 - ATTEMPTED TO READ IN TO MANY OBSTACLE CELLS         VARP.246
   1125          IF(NOB.LE.1200) GO TO 1310                                          VE3.19
   1127     134 WRITE(VDO,20)                                                        VARP.248
   1133          ERF=1                                                               VARP.249
   1134          GO TO 99999                                                         VARP.250
   1135    1310  CONTINUE                                                            VARP.251
   1135          WRITE(VDO,21)                                                       VARP.252
   1141          DO 1320 I=1,NOB                                                     VARP.253
   1145          IJK=OBLOC(I)-1                                                      VARP.254
   1147          JJ=1+IJK/I2K2                                                       VARP.255
   1151          II=1+(IJK-(I2K2*(JJ-1)))/K2NC                                       VARP.256
   1157          KK=1+(IJK-(K2NC*(II-1))-(I2K2*(JJ-1)))/NWPC                         VARP.257
   1171    1320  WRITE(VDO,24) I,OBTYP(I),OBLOC(I),II,JJ,KK                          VARP.258
         C ***** THIS SECTION , 135 , READS AND PRINTS GRAPH OPTIONS FOR SUB VRIOVARP.259
   1216     135 IF( NGOP.LT.1 ) GO TO 140                                            VARP.260
   1221          IF( NGOP.GT.6 ) NGOP=6                                              VARP.261
   1224          READ(VDI,5) (IGOP(I),I=1,NGOP)                                      VARP.262
   1233          WRITE(VDO,6) (IGOP(I),I=1,NGOP)                                     VARP.263
         C ***** THIS SECTION, 140 , READS AND PRINTS CONTOUR PLOT VALUES            VARP.264
   1242     140 LT=0                                                                 VARP.265
   1243          IF( NOVP.LT.1 ) GO TO 160                                           VARP.266
   1246          READ(VDI,7) (VNTP(M),NCVTP(M),M=1,NOVP)                             VARP.267
   1264          DO 149 M=1,NOVP                                                     VARP.268
   1266          WRITE(VDO,9) VNTP(M),NCVTP(M)                                       VARP.269
   1277          LT=NCVTP(M)                                                         VARP.270
   1301          IF( VNTP(M).GT.6 ) GO TO 146                                        VARP.271
   1305          IF( LT.LT.101 ) GO TO 148                                           VARP.272
         C ***** *** ERROR 002 - ATTEMPTED TO READ IN MORE THAN 100 CONTUR PLT VAVARP.273
   1307     145 WRITE(VDO,8)                                                         VARP.274
   1313          ERF=1                                                               VARP.275
   1314          GO TO 99999                                                         VARP.276
         C ***** *** ERROR 009 - NUMBER OF CONTOURS VARIABLES TO BE PLOTTED EXCEOVARP.277
   1315     146 WRITE(VDO,15)                                                        VARP.278
   1321          ERF=1                                                               VARP.279
   1322          GO TO 99999                                                         VARP.280
   1323     148 CONTINUE                                                             VARP.281
   1323     149 CONTINUE                                                             VARP.282
   1326     160 CONTINUE                                                             VARP.283
         C ***** THIS SECTION , 180 , READS IN GRAPHICS QUANTITIES.                  VARP.284
   1326          IF( PRFLM.LT.1 ) GO TO 200                                          VARP.285
         C ***** THIS SECTION READS IN PLANES TO PLOT.                               VARP.286
   1331         READ(VDI,16) IPMM,(IPM(M),M=1,IPMM)                              VAMP.287
   1341         READ(VDI,16) JPMM,(JPM(M),M=1,JPMM)                              VAMP.288
   1352         READ(VDI,16) KPMM,(KPM(M),M=1,KPMM)                              VAMP.289
   1363         READ(VDI,18) IPPP,JPPP,KPPP,IPROJ                                VAMP.290
   1377         WRITE(VDO,36) IPMM,(IPM(M),M=1,IPMM)                             VAMP.291
   1410         WRITE(VDO,37) JPMM,(JPM(M),M=1,JPMM)                             VAMP.292
   1421         WRITE(VDO,38) KPMM,(KPM(M),M=1,KPMM)                             VAMP.293
   1432         WRITE(VDO,40) IPPP,JPPP,KPPP,IPROJ                               VAMP.294
          C ***** THIS SECTION READS IN EYE,MESH PROJECTIONIAL COORDINATES.      VAMP.295
   1446         IF( IPROJ.LT.1 ) GO TO 200                                       VAMP.296
   1451         READ(VDI,17)  NPV,NEC,(PEC(I),I=1,NEC)                           VAMP.297
   1463         READ(VDI,17) NPV,NMC,(PMC(I),I=1,NMC)                            VAMP.298
   1476         WRITE(VDO,39) NPV,NEC,(PEC(I),I=1,NEC)                           VAMP.299
   1511         WRITE(VDO,41) NPV,NMC,(PMC(I),I=1,NMC)                           VAMP.300
   1524         DO 189 I=1,NEC                                                   VAMP.301
   1526         PEC(I)=PEC(I)+EM6                                                VAMP.302
   1530         IF( PEC(I).LT.0.0 ) PEC(I)=PEC(I)-2.*EM6                         VAMP.303
   1535     189 CONTINUE                                                         VAMP.304
          C ***** THIS SECTION, 200 , INITIALIZES ALL ARRAYS TO ZERO             VAMP.305
   1540     200 L1=1                                                             VAMP.306
   1541         L2=IJKMX                                                         VAMP.307
   1543     210 DO 219 L=L1,L2                                                   VAMP.308
   1550         A(L)=0.0                                                         VAMP.309
   1551     219 CONTINUE                                                         VAMP.310
   1552     230 L2=LPARTC                                                        VAMP.311
   1554         DO 239 L=L1,L2                                                   VAMP.312
   1561         PTM(L)=0.0                                                       VAMP.313
   1562     239 CONTINUE                                                         VAMP.314
          C ***** THIS SECTION , 300 , INITIALIZES VELOCITIES AND DX,DY,DZ.      VAMP.315
   1563     300 JJ=1-I2K2                                                        VAMP.316
   1565         DO 329 J=1,JBP2                                                  VAMP.317
   1570         JJ=JJ+I2K2                                                       VAMP.318
   1571         KK=-K2NC                                                         VAMP.319
   1572         DY(J)=DYC                                                        VAMP.320
   1574         RDY(J)=1./DY(J)                                                  VAMP.321
   1576         DO 329 I=1,IBP2                                                  VAMP.322
   1600         KK=KK+K2NC                                                       VAMP.323
   1601         LNPC=-NNPC                                                       VAMP.324
   1602         DX(1)=DXC                                                        VAMP.325
   1604         DX(I)=DXC                                                        VAMP.326
   1605         RDX(I)=1./DX(I)                                                  VAMP.327
   1606         DO 329 K=1,KBP2                                                  VAMP.328
   1610         LNPC=LNPC+NNPC                                                   VAMP.329
   1612         IJK=JJ+KK+LNPC                                                   VAMP.330
   1614         DZ(1)=DZC                                                        VAMP.331
   1616         DZ(K)=DZC                                                        VAMP.332
   1617         RDZ(K)= 1./DZ(K)                                                 VAMP.333
   1620         U(IJK)=U1                                                        VAMP.334
   1623         V(IJK)=V1                                                        VAMP.335
   1624         W(IJK)=W1                                                        VAMP.336
   1626         IF(I.EQ.1.OR.J.EQ.1.OR.K.EQ.1) GO TO 329                         VAMP.337
   1637         IF( I.EQ.IBP2.OR.J.EQ.JBP2.OR.K.EQ.KBP2) GO TO 329               VAMP.338
   1651         VOL(IJK)= DX(I)*DY(J)*DZ(K)                                      VAMP.339
   1656     329 CONTINUE                                                         VAMP.340
          C ***** THIS SECTION,330-339, INITIALIZES VOLUME SEGMENTS.             VAMP.341
   1666         D8= 1./8.                                                        VAMP.342
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VRS
  1667         JJ=1-I2K2                                                        VARP.383
  1671         DO 339 J=1,JBP1                                                  VARP.384
  1673         JJ= JJ+I2K2                                                      VARP.385
  1674         KK= -K2NC                                                        VARP.386
  1676         DO 339 I=1,IBP1                                                  VARP.387
  1677         KK= KK+K2NC                                                      VARP.388
  1700         LWPC= -NWPC                                                      VARP.389
  1702         DO 339 K=1,KBP1                                                  VARP.350
  1713         LWPC= LWPC+NWPC                                                  VARP.351
  1715         IJK= JJ+KK+LWPC                                                  VARP.352
  1717         IPJK= IJK+K2NC                                                   VARP.353
  1720         IJPK= IJK+I2K2                                                   VARP.354
  1722         IJKP= IJK+NWPC                                                   VARP.355
  1720         IPJKP= IJKP+K2NC                                                 VARP.356
  1725         IJPKP= IJPK+NWPC                                                 VARP.357
  1725         IPJPK= IPJK +I2K2                                                VARP.358
  1726         IPJPKP= IPJPK+NWPC                                               VARP.359
  1727         VOL(IJK)= D8*(VOL(IJK)+ VOL(IPJK)+ VOL(IJPK)+ VOL(IJKP)+ VOL(IPJKPVARP.360
              1 ) + VOL(IJPKP)+ VOL(IPJPK)+ VOL(IPJPKP))                        VARP.361
  1745     339 CONTINUE                                                         VARP.362
       C ***** THIS SECTION , 350-379 , INITIALIZED MESH COORDINATES.           VARP.363
  1762         XT=-DX                                                           VARP.364
  1763         DO 359 I=1,IBP2                                                  VARP.365
  1771         XT=XT+DX(I)                                                      VARP.366
  1772     359 X(I)=XT                                                          VARP.367
  1774         ZT=-DZ                                                           VARP.368
  1775         DO 369 K=1,KBP2                                                  VARP.369
  2003         ZT=ZT+DZ(K)                                                      VARP.370
  2004     369 Z(K)=ZT                                                          VARP.371
  2006         YT=-DY                                                           VARP.372
  2007         DO 379 J=1,JBP2                                                  VARP.373
  2015         YT=YT+DY(J)                                                      VARP.374
  2016     379 Y(J)=YT                                                          VARP.375
  2020         XML=X(IMP1)                                                      VARP.376
  2021         YML=Y(JMP1)                                                      VARP.377
  2023         ZML=Z(KMP1)                                                      VARP.378
       C ***** THIS SECTION, 380-419, CALCULATES FINAL CELL VOLUMES             VARP.379
       C       CELL VOLUME IS CENTERED IN THE UPPER RIGHT FORE CORNER OF        VARP.380
       C       THE CELL.                                                        VARP.381
  2026         PRINT 49                                                         VARP.382
            49 FORMAT( 5H    I,4H   J,4H   K,6H  IJK ,12HFINAL VOLUME /)        VARP.383
  2031         D16= 1./16.                                                      VARP.384
  2032         IF(NOB.LT.1) GO TO 400                                           VARP.385
  2035         DO 399 L=1,NOB                                                   VARP.386
  2040         IOB= OBTYP(L).AND.FM                                             VARP.387
  2042         IOB= IOB+1                                                       VARP.388
  2043         IJK= OBLOC(L)-1                                                  VARP.389
  2044         JJ= 1+IJK/I2K2                                                   VARP.390
  2047         II= 1+ (IJK-(I2K2*(JJ-1))) /K2NC                                 VARP.391
  2055         KK= 1+ (IJK-(K2NC *(II-1))-(I2K2*(JJ-1))) /NWPC                  VARP.392
  2067         IJK= IJK+1                                                       VARP.393
  2070         VIJKM= D16*DX(II)*DY(JJ)*DZ(KK)                                  VARP.394
  2075         DBV= 2.*VIJKM                                                    VARP.395
  2077         ILJK= IJK -K2NC                                                  VARP.396
  2101         ILJAK= ILJK-I2K2                                                 VARP.397
  2102         IJAK= IJK -I2K2                                                  VARP.398
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VR8
     2103           IJKB= IJK -NNPC                                                 VARP.399
     2104           ILJKB= IJKB-K2NC                                                VARP.400
     2105           ILJAKB= ILJKB-I2K2                                              VARP.401
     2106           IJAKB= IJKB-I2K2                                                VARP.402
     2110           GO TO (380,381,382,383,384,385,386,387,388,389,390,391,392), IUB VARP.403
     2131       380 IM1= IJK                                                        VARP.404
     2132           IM2= ILJK                                                       VARP.405
     2134           IM3= ILJAK                                                      VARP.406
     2135           IM4= IJAK                                                       VARP.407
     2137           IM5= IJKB                                                       VARP.408
     2140           IM6= ILJKB                                                      VARP.409
     2142           IM7= ILJAKB                                                     VARP.410
     2143           IM8= IJAKB                                                      VARP.411
     2145           GO TO 394                                                       VARP.412
     2146       381 IM1= IJAKB                                                      VARP.413
     2147           IM2= ILJAK                                                      VARP.414
     2151           IM3= IJKB                                                       VARP.415
     2152           IM4= ILJK                                                       VARP.416
     2154           IM1= ILJAKB                                                     VARP.417
     2155           IM2= ILJKB                                                      VARP.418
     2157           GO TO 393                                                       VARP.419
     2160       382 IM1= ILJAKB                                                     VARP.420
     2161           IM2= IJAK                                                       VARP.421
     2163           IM3= ILJKB                                                      VARP.422
     2164           IM4= IJK                                                        VARP.423
     2166           IM1= IJAKB                                                      VARP.424
     2167           IM2= IJKB                                                       VARP.425
     2171           GO TO 393                                                       VARP.426
     2172       383 IM1= ILJAK                                                      VARP.427
     2173           IM2= ILJKB                                                      VARP.428
     2175           IM3= IJAK                                                       VARP.429
     2176           IM4= IJKB                                                       VARP.430
     2200           IM1= ILJAKB                                                     VARP.431
     2201           IM2= IJAKB                                                      VARP.432
     2203           GO TO 393                                                       VARP.433
     2204       384 IM1= ILJAKB                                                     VARP.434
     2205           IM2= ILJK                                                       VARP.435
     2207           IM3= IJAKB                                                      VARP.436
     2210           IM4= IJK                                                        VARP.437
     2212           IM1= ILJKB                                                      VARP.438
     2213           IM2= IJKB                                                       VARP.439
     2215           GO TO 393                                                       VARP.440
     2216       385 IM1= ILJAKB                                                     VARP.441
     2217           IM2= IJAK                                                       VARP.442
     2221           IM3= ILJKB                                                      VARP.443
     2222           IM4= IJK                                                        VARP.444
     2224           IM1= ILJAK                                                      VARP.445
     2225           IM2= ILJK                                                       VARP.446
     2227           GO TO 393                                                       VARP.447
     2230       386 IM1= IJAKB                                                      VARP.448
     2231           IM2= ILJAK                                                      VARP.449
     2233           IM3= IJKB                                                       VARP.450
     2234           IM4= ILJK                                                       VARP.451
     2236           IM1= IJAK                                                       VARP.452
     2237           IM2= IJK                                                        VARP.453
     2241           GO TO 393                                                       VARP.454
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VRS
     2242     387 IM1= ILJK                                                      VARP.455
     2243         IM2= ILJAKB                                                    VARP.456
     2245         IM3= IJK                                                       VARP.457
     2246         IM4= IJAKB                                                     VARP.458
     2250         IM1= ILJAK                                                     VARP.459
     2251         IM2= IJAK                                                      VARP.460
     2253         GO TO 393                                                      VARP.461
     2254     388 IM1= IJAK                                                      VARP.462
     2255         IM2= IJKB                                                      VARP.463
     2257         IM3= ILJAK                                                     VARP.464
     2260         IM4= ILJKB                                                     VARP.465
     2262         IM1= IJK                                                       VARP.466
     2263         IM2= ILJK                                                      VARP.467
     2265         GO TO 393                                                      VARP.468
     2266     389 IM1= IJAKB                                                     VARP.469
     2267         IM2= ILJKB                                                     VARP.470
     2271         IM3= IJAK                                                      VARP.471
     2272         IM4= ILJK                                                      VARP.472
     2274         IM1= ILJAKB                                                    VARP.473
     2275         IM2= ILJAK                                                     VARP.474
     2277         GO TO 393                                                      VARP.475
     2300     390 IM1= ILJAKB                                                    VARP.476
     2301         IM2= IJKB                                                      VARP.477
     2303         IM3= ILJAK                                                     VARP.478
     2304         IM4= IJK                                                       VARP.479
     2306         IM1= ILJKB                                                     VARP.480
     2307         IM2= ILJK                                                      VARP.481
     2311         GO TO 393                                                      VARP.482
     2312     391 IM1= ILJAKB                                                    VARP.483
     2313         IM2= IJKB                                                      VARP.484
     2315         IM3= ILJAK                                                     VARP.485
     2316         IM4= IJK                                                       VARP.486
     2320         IM1= IJAKB                                                     VARP.487
     2321         IM2= IJAK                                                      VARP.488
     2323         GO TO 393                                                      VARP.489
     2324     392 IM1= IJAKB                                                     VARP.490
     2325         IM2= IJAK                                                      VARP.491
     2327         IM3= ILJKB                                                     VARP.492
     2330         IM4= ILJK                                                      VARP.493
     2332         IM1= IJKB                                                      VARP.494
     2333         IM2= IJK                                                       VARP.495
     2342     393 VOL(IM1)= VOL(IM1)-     VIJKM                                  VARP.496
     2344         VOL(IM2)= VOL(IM2)-     VIJKM                                  VARP.497
     2345         VOL(IM3)= VOL(IM3)-     VIJKM                                  VARP.498
     2346         VOL(IM4)= VOL(IM4)-     VIJKM                                  VARP.499
     2352     394 VOL(IM1)= VOL(IM1)-DBV                                         VARP.500
     2353         VOL(IM2)= VOL(IM2)-DBV                                         VARP.501
     2354         IF (IDM.GT.1) GO TO 399                                        VARP.502
     2366         VOL(IM3)= VOL(IM3)-DBV                                         VARP.503
     2370         VOL(IM4)= VOL(IM4)-DBV                                         VARP.504
     2371         VOL(IM5)= VOL(IM5)-DBV                                         VARP.505
     2372         VOL(IM6)= VOL(IM6)-DBV                                         VARP.506
     2374         VOL(IM7)= VOL(IM7)-DBV                                         VARP.507
     2375         VOL(IM8)= VOL(IM8)-DBV                                         VARP.508
     2376     399 CONTINUE                                                       VARP.509
     2401     400 CONTINUE                                                       VARP.510
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VRS
   2401     905 CONTINUE                                                          VAMP.524
   2401         CALL FILMCO                                                       VAMP.525
   2402   99999 RETURN                                                            VAMP.526
   2403         END                                                               VAMP.527


SUBPROGRAM LENGTH

03222

FUNCTION ASSIGNMENTS

STATEMENT ASSIGNMENTS
1      - 002407    2      - 002416    3      - 002421    4      - 002424    5      - 002433    6      - 002436
7      - 002442    8      - 002445    9      - 002457    10     - 002464    11     - 002467    12     - 002477
13     - 002502    14     - 002504    15     - 002510    16     - 002522    17     - 002525    18     - 002531
20     - 002534    21     - 002543    22     - 002556    23     - 002562    24     - 002577    25     - 002604
26     - 002607    30     - 002614    31     - 002636    32     - 002654    33     - 002671    34     - 002703
35     - 002711    36     - 002727    37     - 002733    38     - 002737    39     - 002743    40     - 002751
41     - 002761    49     - 003010    100    - 000002    120    - 000332    124    - 000364    125    - 000450
127    - 000463    130    - 000471    132    - 000733    134    - 001130    135    - 001217    140    - 001243
145    - 001310    146    - 001316    148    - 001324    149    - 001324    160    - 001327    189    - 001536
200    - 001541    210    - 001544    230    - 001553    300    - 001564    329    - 001657    380    - 002152
381    - 002147    382    - 002161    383    - 002173    384    - 002205    385    - 002217    386    - 002231
387    - 002243    388    - 002255    389    - 002267    390    - 002301    391    - 002313    392    - 002325
393    - 002336    394    - 002350    399    - 002377    400    - 002402    905    - 002402    1000   - 000710
1010   - 000612    1020   - 000617    1030   - 000624    1040   - 000631    1050   - 000636    1060   - 000643
1070   - 000650    1080   - 000655    1090   - 000662    1100   - 000667    1110   - 000674    1120   - 000701
1200   - 000706    1310   - 001136    1330   - 001054    99999  - 002403

BLOCK NAMES AND LENGTHS
  *LCM&- 0127710
VRCOM  - 106290/01   CONCEN - 000132/02   AMIX   - 001130/03   FL     - 000035/04   FLS    - 000011/05   VRCON  - 006352/06
MODSET - 000310/07   SAFLM  - 000447/08   ZLAST  - 000001/11

VARIABLE ASSIGNMENTS
A      - 000000/01   ALX    - 000000/06   ALY    - 000001/06   ALZ    - 000002/06   AKGS   - 000036/02   BUFL   - 000004/06
BO     - 000003/06   C      - 000000/03   CEP    - 000005/06   CON    - 0072460/LC CPRT   - 003075      CU     - 000004/01
COF    - 000005/01   DROU   - 000435/06   D1     - 000006/06   DX     - 000007/06   DXC    - 000127/06   DY     - 000130/06
DYC    - 000250/06   DZ     - 000251/06   DZC    - 000371/06   D16    - 003174      D8     - 003166      DBV    - 003176
EMO    - 000372/06   EM6    - 000373/06   EMF    - 000374/06   F      - 003072      FACS   - 000050/02   FH     - 000024/04
FFX3'  - 000021/08   FFY3   - 000134/08   FI     - 000000/05   FM     - 000030/04   FU     - 000000/04   GPX    - 000375/06
GPY    - 000376/06   GPZ    - 000377/06   GX     - 000400/06   GY     - 000401/06   GZ     - 000402/06   I      - 003141
IBR    - 003140      IHP1   - 000403/06   IHP2   - 000404/06   IHR    - 000405/06   IFLG   - 000016/08   IGOP   - 000411/06
IH1    - 003216      IH2    - 003217      IH3    - 003220      IH4    - 003221      II     - 003157      IJAK   - 003201
IJAKB  - 003205      IJK    - 003145      IJKB   - 003202      IJKL   - 003155      IJKM   - 003146      IJKMX  - 000417/06
IJKNC  - 000420/06   IJKP   - 003147      IJK2   - 000421/06   IJMK   - 003150      IJPK   - 003151      IJPKP  - 003170
IJP1K  - 000422/06   IKP2   - 000427/06   IL     - 003131      ILJAK  - 003200      ILJAKB - 003204      ILJK   - 003177
ILJKB  - 003203      IMJK   - 003152      IM1K2  - 003126      IOR    - 003144      IPEDIT - 000062/02   IPFL   - 000074/02
IPFS   - 000106/02   IPJK   - 003153      IPJKP  - 003167      IPJPK  - 003171      IPJPKP - 003172      IPM    - 000302/08
IPMM   - 000326/08   IPPP   - 000327/08   IPROJ  - 000330/08   IR     - 003132      ISFLG  - 000432/06   ITCYC  - 000247/08
IW1    - 003206      IW2    - 003207      IW3    - 003210      IW4    - 003211      IW5    - 003212      IW6    - 003213
IW7    - 003214      IW8    - 003215      I1K2   - 003125      I2JK2  - 000426/06   I2K2   - 000441/06   J      - 003142
JA     - 003133      JBP1   - 000442/06   JBP2   - 000443/06   JBR    - 000444/06   JF     - 003134      JJ     - 003156
JNC    - 000450/06   JPM    - 000331/08   JPMM   - 000355/08   JPPP   - 000356/08   J2NC   - 000453/06   K      - 003143
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          SUBROUTINE VRM                                                        VARP.729
          INTEGER E,ERF,VDI,VDO,BUFL,PYML,PXML,CPRT,VNTP,VTP,PF,ID,TD1,TD2,     INREAL.2
         1 PRFLM,COF,SHIFT,OBLOC,OBTYP,FI,FO,FB,FM,OBTYPL                       INREAL.3
          REAL NU                                                               INREAL.4
    C                                                                           INREAL.5
          DIMENSION U(1),V(1),W(1),P(1),CQ(1),CQF(1)                            DIMEN.2
         1 ,VOL(1)                                                              DIMEN.3
          DIMENSION SPEC(10),TSP(10)                                            VF3.1
          DIMENSION TA(1),UCON(1)                                               DIMEN.6
    C                                                                           DIMEN.7
          COMMON/VRCOM/A(36000)                                                 VF3.2
          COMMON/CONCEN/ NSPS(10),PMAXMS(10),PMINMS(10),BKGS(10),FACS(10)       VF3.3
         1 ,IPEDIT(10),IPEL(10),IPES(10),PMIN(10)                               VF3.4
          COMMON /AMIX/ C(600)                                                  COMM.5
          COMMON/FL/FO(20),FB(8),FM                                             COMM.6
          COMMON/ELS/FI(9)                                                      COMM.7
          COMMON/VRCON/ALX,ALY,ALZ,BU,BUFL,CEP,DT,DX(80),DXC,DY(80),DYC,        VF3.5
         1 DZ(80),DZC,EMO,EM6,ERF,GPX,GPY,GPZ,GX,GY,GZ,IBP1,IBP2,IBR,IBRED,     VF3.6
         2 IBRIN,IBRST,IGOP(6),IJKMX,IJKNC,IJK2,IJP1K,IPL,IPR,ITER,I2JK2,       COMM.10
         * IBP2,IPARTF,IPLIF,ISELG,RIBJBKB,LPR,DROU,                            COMM.11
         *IJKCON,ICON,JCON,                                                     COMM.12
         3 I2K2,JBP1,JBP2,JBR,JBRED,JBRIN,JBRST,JNC,JPA,JPF,J2NC,KBP1,KBP2,     COMM.13
         4 KBR,KBRED,KBRIN,KBRST,KFP,KNC,KPB,KPT,KWA,KWB,KWF,KWL,KWR,KWT,       COMM.14
         5 K2NC,LABEL(8),LNPART,LNVRCM,LPARTC,NCIP,NCVIP(6),NCYC,NGOP,NOPI,     COMM.15
         *NOCONC,                                                               COMM.16
         * OBLOC(1200),OBTYP(1200),MUB,NU,                                      VF3.7
         6 NOVP,NOVS,NPMX,NPRT,NTPE,NWPC,NWPP,PDX,PDY,PDZ,PI,PRFLM,ROT,         COMM.18
         7 RDX(80),RDY(80),RDZ(80),RRAN(20),SIGMA,ID,TD1,TD2,TFIN,TIMET,TIP,    VF3.8
         8 TPL,TPLT,TPR,TPRT,TTD,TWIP,TWTD,UI,UPI,VDI,VDO,VI,VNTP(6),VPI,       COMM.20
         9 VTP,WI,WPI,ARAN(20),X(80),XPCEN,Y(80),YPCEN,Z(80),ZPCEN              VF3.9
          COMMON /MODSET/ SCFLM(200)                                            COMM.22
          COMMON /SAFLM/ XCONV,ZCONV,FX1,FX2,FX3,FX4,FY1,FY2,FY3,FY4,           COMM.23
         1 FXL,FYR,PAL,PYR,IFLM(3),FFX3(75),FFY3(75)                            COMM.24
         2 ,ITCYC(3),XFC1(4),XFC2(4),YFC1(4),YFC2(4),PBTIM(2),XML,YML,ZML       COMM.25
         3 ,IFMID,IFTEST,IPLOPT,IPM(20),IPMM,IPPP,IPROJ,JPM(20),JPMM,JPPP,      COMM.26
         4 KPM(20),KPMM,KPPP,NEC,NMC,NPS,NPV,PEC(10),PMC(10),YCONV              COMM.27
         5 ,IFLAB,IFLIN,IFPN1,IFOP1,NCH,XFSP,XT,YFSP,YT                         COMM.28
          COMMON /ZLAST/ ZLAS                                                   COMM.29
    C                                                                           COMM.30
          EQUIVALENCE (A(1),U),(A(2),V),(A(3),W),(A(4),P),(A(5),CQ),            EQUIV.2
         1 (A(6),CQF), (A(7),VOL)                                               EQUIV.3
          EQUIVALENCE (C(1),TA,UCON)                                            EQUIV.7
    C                                                                           EQUIV.8
        1 FORMAT(1H ,46H *** ENTERED SUBROUTINE VRM - MAIN PROGRAM ***)         VARP.730
        2 FORMAT(1H ,72H *** ERROR 008 - PRESSURES FAILED TO CONVERGE WITHINVARP.731
         1 1000 ITERATIONS ***)                                                 VARP.732
        3 FORMAT(1H ,8H PMAX = ,1PE12.5)                                        VARP.733
        4 FORMAT(1H ,6HTIMET=,1PE12.5,2X,5HITER=,I5)                            VARP.734
        5 FORMAT(1H ,17H *** GRIND TIME =,1PE12.5,3X,7H AT T =,E12.5)           VARP.735
          WRITE(VDO,1)                                                          VARP.736
    C ***** THIS INITIALIZES PMAX FOR PRESSURE ITERATION                        VARP.737
5     900 PMAX=EM6                                                              VARP.738
    C ***** THE FOLLOWING CONSTANTS DEFINE THE LIMITS OF THE PRINT LOOPS IN     VARP.739
6         IBRST=2                                                               VARP.740
7         IBRED=IBP1                                                            VARP.741
11        IBRIN=1                                                               VARP.742
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VRM
  12.        KMRST=2                                                          VARP.743
  13         IUMAX= 0                                                         VE3.20
  14         KBRED=KMP1                                                       VARP.744
  15         KBRIN=1                                                          VARP.745
  16         JBRST=2                                                          VARP.746
  17         JBRED=JBP1                                                       VARP.747
  21         JBRIN=1                                                          VARP.748
      C ***** THIS SECTION, 1000 , CALCULATES CONSTANTS                       VARP.749
  22  1000   CALL SECOND(S1)                                                  VARP.750
  24         ASSIGN 2000 TO KBC                                               VARP.751
  25         IHCF=2000                                                        VARP.752
      C   ***    ISFLG IS FLAG FOR NO SLIP BOUNDRY ON FLOOR AND OBSTACLES.    VARP.753
      C      ISFLG=0 FREE SLIP,    ISFLG=1 NO SLIP                            VARP.754
  26         ITER=0                                                           VARP.755
      C ***** IF IPARTF=1, THEN HYDRO WILL BE BYPASSED.                       VARP.756
  27         IPARTF= 0                                                        VE3.21
  30  1040   IF( IBR.EQ.0 ) GO TO 7500                                        VARP.761
      C ***** THIS SECTION,1100 TO 1900 , CALCULATES BOUNDARY CONDITIONS      VARP.762
      C ***** THIS SECTION , 1100-1289 , CAL WALL RIGHT + LEFT BNDRY COND.    VARP.763
  31  1100   JJ=1-I2K2                                                        VARP.764
  33         DO 1289 J=1,JBP2                                                 VARP.765
  35         JJ=JJ+I2K2                                                       VARP.766
  36         LWPC=-NWPC                                                       VARP.767
  40         DO 1289 K=1,KBP2                                                 VARP.768
  41         LWPC=LWPC+NWPC                                                   VARP.769
  42         IMJK=JJ+LWPC                                                     VARP.770
  43         V(IMJK)=V(IMJK+K2NC)                                             VARP.771
  47         W(IMJK)=W(IMJK+K2NC)                                             VARP.772
  51         IPJK=IBP2+IMJK                                                   VARP.773
  52         V(IPJK+K2NC)=V(IPJK)                                             VARP.774
  55         W(IPJK+K2NC)=W(IPJK)                                             VARP.775
  60         GO TO( 1140,1150,1160 ),KWL                                      VARP.776
      C ***** THIS SECTION, 1140 , CALCULATES RIGID WALL LEFT BNDRY COND      VARP.777
  70  1140   U(IMJK)=0.0                                                      VARP.778
      C  ********* INFLOW BOUNDRY CONDITION         *                         VARP.779
  71         U(IMJK)=  1.0                                                    VE3.22
  73         IF( ISFLG.EQ.0) GO TO 1180                                       VE3.23
  75         W(IMJK)= -W(IMJK+K2NC)                                           VE3.24
  77         V(IMJK)= -V(IMJK+K2NC)                                           VE3.25
 101         GO TO 1180                                                       VARP.781
      C ***** THIS SECTION, 1150 , CALCULATES CONTINUATIVE BNDRY COND         VARP.782
 102  1150   IF( ITER.GT.0 ) GO TO 1180                                       VARP.783
 105         U(IMJK)=U(IMJK+K2NC)                                             VARP.784
 110         GO TO 1180                                                       VARP.785
      C ***** THIS SECTION, 1160 , CALCULATES PERIODIC WALL LEFT BNDRY COND   VARP.786
 110  1160   U(IMJK)=U(IPJK)                                                  VARP.787
 113  1180   CONTINUE                                                         VARP.788
      C ***** THIS SECTION, 1200 , CALCULATES WALL RIGHT BOUNDARY CONDITIONS  VARP.789
 113         GO TO( 1240,1250,1260 ),KWR                                      VARP.790
      C ***** THIS SECTION, 1240 , CALCULATES RIGID WALL RIGHT BNDRY COND     VARP.791
 122  1240   U(IPJK)=0.0                                                      VARP.792
 124         IF( ISFLG.EQ.0) GO TO 1280                                       VE3.26
 126         W(IPJK+K2NC)= -W(IPJK)                                           VE3.27
 130         V(IPJK+K2NC)= -V(IPJK)                                           VE3.28
 133         GO TO 1280                                                       VARP.793
      C ***** THIS SECTION, 1250 , CALCULATES CONTINUATIVE WALL RIGHT BNDRY COVARP.794
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VRM
      133  1250  IF( ITER.GT.0 ) GO TO 1280                                   VARP.795
      136        U(IPJK)=U(IPJK-K2NC)                                         VARP.796
      141        GO TO 1280                                                   VARP.797
           C ***** THIS SECTION, 1260 , CALCULATES PERIODIC WALL RIGHT BNDRY COND  VARP.798
      141  1260  U(IPJK+K2NC)=U(IMJK+K2NC)                                    VARP.799
      145  1280  CONTINUE                                                     VARP.800
      145  1289  CONTINUE                                                     VARP.801
           C ***** THIS SECTION, 1300 TO 1490 , CAL WALL TOP + BOTTOM BNDRY COND  VARP.802
           C ***** THIS SECTION, 1300 , CALCULATES WALL TOP BOUNDARY CONDITIONS   VARP.803
      152  1300  JJ=1-I2K2                                                    VARP.804
      154        DO 1489 J=1,JBP2                                             VARP.805
      156        JJ=JJ+I2K2                                                   VARP.806
      157        KK=-K2NC                                                     VARP.807
      161        DO 1489 I=1,IBP2                                             VARP.808
      162        KK=KK+K2NC                                                   VARP.809
      163        IJKM=JJ+KK                                                   VARP.810
      164        U(IJKM)=U(IJKM+NWPC)                                         VARP.811
      170        V(IJKM)=V(IJKM+NWPC)                                         VARP.812
      172        IJKP=IJKM+KNC                                                VARP.813
      173        U(IJKP+NWPC)=U(IJKP)                                         VARP.814
      176        V(IJKP+NWPC)=V(IJKP)                                         VARP.815
      201        GO TO( 1340,1350,1360 ),KWT                                  VARP.816
           C ***** THIS SECTION, 1340 , CALCULATES RIGID WALL TOP BNDRY COND      VARP.817
      210  1340  W(IJKP)=0.0                                                  VARP.818
      212        IF( ISFLG.EQ.0) GO TO 1380                                   VE3.29
      214        U(IJKP+NWPC)= -U(IJKP)                                       VE3.30
      216        V(IJKP+NWPC)= -V(IJKP)                                       VE3.31
      221        GO TO 1380                                                   VARP.819
           C ***** THIS SECTION, 1350 , CALCULATES CONTINUATIVE WALL TOP BNDRY CONDVARP.820
      221  1350  IF( ITER.GT.0 ) GO TO 1380                                   VARP.821
      224        W(IJKP)=W(IJKP-NWPC)                                         VARP.822
      227        GO TO 1380                                                   VARP.823
           C ***** THIS SECTION, 1360 , CALCULATES PERIODIC WALL TOP BNDRY COND   VARP.824
      227  1360  W(IJKP+NWPC)=W(IJKM+NWPC)                                    VARP.825
      233  1380  CONTINUE                                                     VARP.826
           C ***** THIS SECTION, 1400 , CALCULATES WALL BOTTOM BOUNDARY CONDITIONS VARP.827
      233  1400  GO TO( 1440,1450,1460 ),KWB                                  VARP.828
           C ***** THIS SECTION, 1440 , CALCULATES RIGID WALL BOTTOM BNDRY COND   VARP.829
      242  1440  W(IJKM)=0.0                                                  VARP.830
      244        IF( ISFLG.EQ.0) GO TO 1480                                   VARP.831
      246        U(IJKM)= -U(IJKM+NWPC)                                       VARP.832
      250        V(IJKM)= -V(IJKM+NWPC)                                       VARP.833
      252        GO TO 1480                                                   VARP.834
           C ***** THIS SECTION, 1450 , CALCULATES CONTINUATIVE WALL BOTTOM BNDRY CVARP.835
      253  1450  IF( ITER.GT.0 ) GO TO 1480                                   VARP.836
      256        W(IJKM)=W(IJKM+NWPC)                                         VARP.837
      261        GO TO 1480                                                   VARP.838
           C ***** THIS SECTION, 1460 , CALCULATES PERIODIC WALL BOTTOM BNDRY COND VARP.839
      261  1460  W(IJKM)=W(IJKP)                                              VARP.840
      264  1480  CONTINUE                                                     VARP.841
      264  1489  CONTINUE                                                     VARP.842
           C ***** THIS SECTION ,1500-1690 , CALCULATES FRONT + AFT BNDRY COND.   VARP.843
           C ***** THIS SECTION , 1500 , CALCULATES WALL FRONT BNDRY COND.        VARP.844
      271  1500  KK=1-K2NC                                                    VARP.845
      273        DO 1689 I=1,IBP2                                             VARP.846
      275        KK=KK+K2NC                                                   VARP.847
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VRM
     276          LWPC=-NWPC                                                      VARP.848
     300          DO 1689 K=1,NBP2                                                VARP.849
     301          LWPC=LWPC+NWPC                                                  VARP.850
     302          IJMK=KK+LWPC                                                    VARP.851
     303          W(IJMK)=W(IJMK+I2K2)                                            VARP.852
     307          U(IJMK)=U(IJMK+I2K2)                                            VARP.853
     311          IJPK=IJMK+I2JK2                                                 VARP.854
     312          W(IJPK+I2K2)=W(IJPK)                                            VARP.855
     315          U(IJPK+I2K2)=U(IJPK)                                            VARP.856
     320          GO TO( 1540,1550,1560 ),KWF                                     VARP.857
           C ***** THIS SECTION , 1540 , CALCULATES RIGID WALL FRONT BNDRY COND.  VARP.858
     327   1540   V(IJPK)=0.0                                                     VARP.859
     331          IF( ISFLG.EQ.0) GO TO 1580                                      VE3.32
     333          U(IJPK+I2K2)= -U(IJPK)                                          VE3.33
     335          W(IJPK+I2K2)= -W(IJPK)                                          VE3.34
     340          GO TO 1580                                                      VARP.860
           C ***** THIS SECTION , 1550 , CALCULATES CONTINUATIVE WALL FRONT BNDRY CVARP.861
     340   1550   IF( ITER.GT.0 ) GO TO 1580                                      VARP.862
     343          V(IJPK)=V(IJPK-I2K2)                                            VARP.863
     346          GO TO 1580                                                      VARP.864
           C ***** THIS SECTION , 1560 , CALCULATES PERIODIC WALL FRONT BNDRY COND.VARP.865
     346   1560   V(IJPK+NWPC)=V(IJMK+NWPC)                                       VARP.866
     352   1580   CONTINUE                                                        VARP.867
           C ***** THIS SECTION , 1600 , CALCULATES WALL AFT BNDRY COND.          VARP.868
     352   1600   GO TO( 1640,1650,1660 ),KWA                                     VARP.869
           C ***** THIS SECTION , 1640 , CALCULATES RIGID WALL AFT BNDRY COND.    VARP.870
     361   1640   V(IJMK)=0.0                                                     VARP.871
     363          IF( ISFLG.EQ.0) GO TO 1680                                      VE3.35
     365          U(IJMK)= -U(IJMK+I2K2)                                          VE3.36
     367          W(IJMK)= -W(IJMK+I2K2)                                          VE3.37
     371          GO TO 1680                                                      VARP.872
           C ***** THIS SECTION , 1650 , CALCULATES CONTINUATIVE WALL AFT BNDRY CONVARP.873
     372   1650   IF( ITER.GT.0 ) GO TO 1680                                      VARP.874
     375          V(IJMK)=V(IJMK+I2K2)                                            VARP.875
     400          GO TO 1680                                                      VARP.876
           C ***** THIS SECTION , 1660 , CALCULATES PERIODIC WALL AFT BNDRY COND. VARP.877
     400   1660   V(IJMK)=V(IJPK)                                                 VARP.878
     403   1680   CONTINUE                                                        VARP.879
     403   1689   CONTINUE                                                        VARP.880
           C *****  THIS SECTION, 1700, CALCULATES OBSTACLE BOUNDRY CONDITIONS    VARP.881
     410   1700   IF(NOB.LE.0) GO TO 1990                                         VARP.882
     412          DO 1720 I=1,NOB                                                 VARP.883
     414          IJK=OBLOC(I)                                                    VARP.884
     415           IMJK=IJK-K2NC                                                  VARP.885
     416           IJPK=IJK-I2K2                                                  VARP.886
     420           IJKM=IJK-NWPC                                                  VARP.887
     421          IOB= OBTYP(I).AND.FM                                            VARP.888
     423          IOB=IOB+1                                                       VARP.889
     425          GO TO (1713,1701,1702,1703,1704,1705,1706,1707,1708,1709,       VARP.890
                 1       1710,1711,1712), IOB                                     VARP.891
     445   1701   CONTINUE                                                        VARP.892
     445          U(IMJK)=0.0                                                     VARP.893
     447          V(IJK)=0.0                                                      VARP.894
     450          V(IJMK)=0.0                                                     VARP.895
     452          W(IJKM)=0.0                                                     VARP.896
     453          GO TO 1720                                                      VARP.897
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VRM
   454.  1702  CONTINUE                                                                VARP.898
   455         U(IJK)=0.0                                                              VARP.899
   456         V(IJK)=0.0                                                              VARP.900
   457         V(IJMK)=0.0                                                             VARP.901
   460         W(IJKM)=0.0                                                             VARP.902
   462         GO TO 1720                                                              VARP.903
   462   1703  CONTINUE                                                                VARP.904
   462         U(IJK)=0.0                                                              VARP.905
   464         U(IMJK)=0.0                                                             VARP.906
   465         V(IJMK)=0.0                                                             VARP.907
   467         W(IJKM)=0.0                                                             VARP.908
   470         GO TO 1720                                                              VARP.909
   471   1704  CONTINUE                                                                VARP.910
   472         U(IJK)=0.0                                                              VARP.911
   473         U(IMJK)=0.0                                                             VARP.912
   475         V(IJK)=0.0                                                              VARP.913
   475         W(IJKM)=0.0                                                             VARP.914
   477         GO TO 1720                                                              VARP.915
   477   1705  CONTINUE                                                                VARP.916
   500         U(IMJK)=0.0                                                             VARP.917
   502         V(IJK)=0.0                                                              VARP.918
   502         V(IJMK)=0.0                                                             VARP.919
   504         W(IJK)=0.0                                                              VARP.920
   504         GO TO 1720                                                              VARP.921
   505   1706  CONTINUE                                                                VARP.922
   506         U(IJK)=0.0                                                              VARP.923
   507         V(IJK)=0.0                                                              VARP.924
   510         V(IJMK)=0.0                                                             VARP.925
   511         W(IJK)=0.0                                                              VARP.926
   512         GO TO 1720                                                              VARP.927
   512   1707  CONTINUE                                                                VARP.928
   513         U(IJK)=0.0                                                              VARP.929
   514         U(IMJK)=0.0                                                             VARP.930
   516         V(IJMK)=0.0                                                             VARP.931
   517         W(IJK)=0.0                                                              VARP.932
   520         GO TO 1720                                                              VARP.933
   520   1708  CONTINUE                                                                VARP.934
   521         U(IJK)=0.0                                                              VARP.935
   522         U(IMJK)=0.0                                                             VARP.936
   524         V(IJK)=0.0                                                              VARP.937
   524         W(IJK)=0.0                                                              VARP.938
   525         GO TO 1720                                                              VARP.939
   525   1709  CONTINUE                                                                VARP.940
   525         U(IMJK)=0.0                                                             VARP.941
   527         V(IJMK)=0.0                                                             VARP.942
   530         W(IJK)=0.0                                                              VARP.943
   532         W(IJKM)=0.0                                                             VARP.944
   533         GO TO 1720                                                              VARP.945
   534   1710  CONTINUE                                                                VARP.946
   535         U(IMJK)=0.0                                                             VARP.947
   537         V(IJK)=0.0                                                              VARP.948
   537         W(IJK)=0.0                                                              VARP.949
   540         W(IJKM)=0.0                                                             VARP.950
   541         GO TO 1729                                                              VARP.951
   542   1711  CONTINUE                                                                VARP.952
   543         U(IJK)=0.0                                                              VARP.953
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  VHM
     544         V(IJMK)=0.0                                                  VARP.954
     546         W(IJK)=0.0                                                   VARP.955
     546         W(IJKM)=0.0                                                  VARP.956
     550         GO TO 1720                                                   VARP.957
     550   1712  CONTINUE                                                     VARP.958
     551         U(IJK)=0.0                                                   VARP.959
     552         V(IJK)=0.0                                                   VARP.960
     553         W(IJK)=0.0                                                   VARP.961
     553         W(IJKM)=0.0                                                  VARP.962
     555         GO TO 1720                                                   VARP.963
     555   1713  CONTINUE                                                     VARP.964
     556         U(IJK)=0.0                                                   VARP.965
     557         U(IMJK)=0.0                                                  VARP.966
     561         V(IJK)=0.0                                                   VARP.967
     561         V(IJPK)=0.0                                                  VARP.968
     563         W(IJK)=0.0                                                   VARP.969
     563         W(IJKM)=0.0                                                  VARP.970
     565   1720  CONTINUE                                                     VARP.971
           C *****  BYPASS NO SLIP BOUNDARIES ONLY FOR PRESSURE ITERATIONS ON VARP.972
           C     ISFLG EQUALS 0                                               VARP.973
     570         IF( IBCF.EQ.4100.OR. ISFLG.EQ.0) GO TO 1770                  VARP.974
     576         DO 1760 I=1,NOB                                              VARP.975
     600         IJK= OBLOC(I)                                                VARP.976
     601         IMJK= IJK-K2NC                                               VARP.977
     602         IJMK= IJK-I2K2                                               VARP.978
     604         IJKM= IJK-NWPC                                               VARP.979
     605         OBTYPL=OBTYP(I)                                              VARP.980
     607         IOB=OBTYPL .AND. FM                                          VARP.981
     610         IOB= IOB+1                                                   VARP.982
     612         IPJK= IJK+K2NC                                               VARP.983
    .613         IJPK= IJK+I2K2                                               VARP.984
     614         IJKP= IJK+NWPC                                               VARP.985
           C *****  TEST FOR DIAGONAL OBSTACLE CELLS                          VARP.986
     616         GO TO (1721,1745,1746,1747,1748,1749,1750,1751,1752,1753,1754, VARP.987
               U       1755,1756) , IOB                                       VARP.988
     637    1721 KT= OBTYPL .AND. FB(1)                                       VARP.989
     641         IR= OBTYPL .AND. FB(2)                                       VARP.990
     642         IL= OBTYPL .AND. FB(3)                                       VARP.991
   . 644         JA= OBTYPL .AND. FB(4)                                       VARP.992
     645         JF= OBTYPL .AND. FB(5)                                       VARP.993
     647         KB= OBTYPL .AND. FB(6)                                       VARP.994
     650         IF(KT.EQ.0) GO TO 1724                                       VARP.995
           C ** TOP FACE EXPOSED      KT                                      VARP.996
    '654    1722 U(IJK)= -U(IJKP)                                             VARP.997
     656         V(IJK)= -V(IJKP)                                             VARP.998
           C *** RIGHT FACE EXPOSED    IR                                     VARP.999
     657    1724 IF(IR.EQ.0) GO TO 1726                                       VARP.1000
     662         W(IJK)= -W(IPJK)                                             VARP.1001
     664         V(IJK)= -V(IPJK)                                             VARP.1002
           C *** LEFT FACE EXPOSED    IL                                      VARP.1003
     665    1726 IF(IL.EQ.0) GO TO 1728                                       VARP.1004
     670         W(IJK)= -W(IMJK)                                             VARP.1005
     672         V(IJK)= -V(IMJK)                                             VARP.1006
           C *** AFT FACE EXPOSED    JA                                       VARP.1007
           C    ***   BYPASS JA AND JF FOR 2-D CALCULATIONS                   VARP.1008
     673    1728 IF(IBR.EQ.1) GO TO 1732                                      VE3.38
```

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VRM
675          IF(JA.EQ.0) GO TO 1730                                     VFS.39
700             U(IJK)= -U(IJMK)                                        VARP.1010
702             W(IJK)= -W(IJMK)                                        VARP.1011
      C *** FRONT FACE EXPOSED    JF                                    VARP.1012
703    1730 IF(JF.EQ.0) GO TO 1732                                      VARP.1013
706             U(IJK)= -U(IJPK)                                        VARP.1014
710             W(IJK)= -W(IJPK)                                        VARP.1015
711    1732 IF(KM.EQ.0) GO TO 1733                                      VARP.1016
714             U(IJK)= -U(IJKM)                                        VARP.1017
716             V(IJK)= -V(IJKM)                                        VARP.1018
      C *****    SET NORMAL FACE VELOCITIES TO ZERO                     VARP.1019
      C KT                                                              VARP.1020
717    1733 IF (KT.EQ.0) GO TO 1734                                     VARP.1021
720             W(IJK)=0.0                                              VARP.1022
      C IR                                                              VARP.1023
722    1734 IF (IR.EQ.0) GO TO 1736                                     VARP.1024
723             U(IJK)=0.0                                              VARP.1025
      C IL                                                              VARP.1026
725    1736 IF (IL.EQ.0) GO TO 1738                                     VARP.1027
726             U(IMJK)=0.0                                             VARP.1028
      C JA                                                              VARP.1029
730    1738 IF (JA.EQ.0) GO TO 1740                                     VARP.1030
731             V(IJMK)=0.0                                             VARP.1031
      C JF                                                              VARP.1032
733    1740 IF (JF.EQ.0) GO TO 1742                                     VARP.1033
734             V(IJK)= 0.0                                             VARP.1034
      C KB                                                              VARP.1035
736    1742 IF (KB.EQ.0) GO TO 1760                                     VARP.1036
737             W(IJKM)= 0.0                                            VARP.1037
741             GO TO 1760                                              VARP.1038
      C *****    DIAGONAL CELLS                                         VARP.1039
741    1745 U(IMJK)= 0.0                                                VARP.1040
743             W(IJKM)= 0.0                                            VARP.1041
744             GO TO 1759                                              VARP.1042
745    1746 U(IJK)= 0.0                                                 VARP.1043
747             W(IJKM)= 0.0                                            VARP.1044
750             GO TO 1759                                              VARP.1045
751    1747 V(IJMK)= 0.0                                                VARP.1046
753             W(IJKM)= 0.0                                            VARP.1047
754             GO TO 1759                                              VARP.1048
755    1748 V(IJK)= 0.0                                                 VARP.1049
757             W(IJKM)= 0.0                                            VARP.1050
760             GO TO 1759                                              VARP.1051
761    1749 W(IJK)= 0.0                                                 VARP.1052
763             U(IMJK)= 0.0                                            VARP.1053
764             GO TO 1759                                              VARP.1054
766    1750 W(IJK)= 0.0                                                 VARP.1055
767             U(IJK)= 0.0                                             VARP.1056
770             GO TO 1759                                              VARP.1057
770    1751 W(IJK)= 0.0                                                 VARP.1058
772             V(IJMK)= 0.0                                            VARP.1059
773             GO TO 1759                                              VARP.1060
775    1752 W(IJK)= 0.0                                                 VARP.1061
776             V(IJK)= 0.0                                             VARP.1062
777             GO TO 1759                                              VARP.1063
777    1753 U(IMJK)= 0.0                                                VARP.1064
```

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VRM
   1001          V(IJMK)= 0.0                                         VARP.1065
   1002          GO TO 1759                                           VARP.1066
   1003    1754  V(IJK)= 0.0                                          VARP.1067
   1005          U(IMJK)= 0.0                                         VARP.1068
   1006          GO TO 1759                                           VARP.1069
   1007    1755  U(IJK)= 0.0                                          VARP.1070
   1011          V(IJMK)= 0.0                                         VARP.1071
   1012          GO TO 1759                                           VARP.1072
   1014    1756  V(IJK)= 0.0                                          VARP.1073
   1015          U(IJK)= 0.0                                          VARP.1074
   1016          GO TO 1759                                           VARP.1075
   1016    1759  CONTINUE                                             VARP.1076
   1016    1760  CONTINUE                                             VARP.1077
   1021    1770  CONTINUE                                             VARP.1078
   1021    1990  GO TO KBC,( 2000,4100,5500 )                         VARP.1079
         C ***** THIS SECTION,2000 TO 2990 , CALCULATES TILDE VELOCITIES VARP.1080
   1024    2000  KFP=0                                                VARP.1081
   1025          IF( NCYC.LT.NPRT ) GO TO 2010                        VARP.1082
   1030          GO TO 2030                                           VARP.1083
   1030    2010  ASSIGN 2030 TO KPRT                                  VARP.1084
   1031          IF( NPRT.LE.1 ) KFP=1                                VARP.1085
   1035    2020  GO TO 6020                                           VARP.1086
   1036    2030  ASSIGN 7000 TO KPRT                                  VARP.1087
         C ***** THIS SECTION, 2100-2109 , STORES U(I-1,K) TO U( STORAGE ARRY )  VARP.1088
   1037    2100  JJ=1                                                 VARP.1089
   1040          KK=-K2NC                                             VARP.1090
   1042          DO 2109 I=1,IBP2                                     VARP.1091
   1043          KK=KK+K2NC                                           VARP.1092
   1044          LWPC=-NWPC                                           VARP.1093
   1046          DO 2109 K=1,KBP2                                     VARP.1094
   1055          LWPC=LWPC+NWPC                                       VARP.1095
   1056          IJK=JJ+KK+LWPC                                       VARP.1096
   1060          IJKS=IJK+IJKNC                                       VARP.1097
   1062          U(IJKS)=U(IJK)                                       VARP.1098
   1063          V(IJKS)=V(IJK)                                       VARP.1099
   1065          W(IJKS)=W(IJK)                                       VARP.1100
   1066    2109  CONTINUE                                             VARP.1101
         C ***** NOW BEGIN MAJOR TILDE VELOCITIES DO LOOPS            VARP.1102
   1073    2200  JJ=1                                                 VARP.1103
   1074          DO 2889 J=2,JBP1                                     VARP.1104
   1077          JJ=JJ+I2K2                                           VARP.1105
   1100          KK=0                                                 VARP.1106
   1101          HRDY=.5*RDY(J)                                       VARP.1107
   1103          RDYA=1./(DY(J)+DY(J+1))                              VARP.1108
   1106          RDYP= 1./DY(J+1)                                     VARP.1109
         C        THIS SECTION TRANSFERS LEFT COLUMN TO STORAGE ARRAY VARP.1110
   1106          LKPC=-NWPC                                           VARP.1111
   1110          DO 2201 K=1,KBP2                                     VARP.1112
   1120          LWPC=LWPC+NWPC                                       VARP.1113
   1121          IJK=JJ+LWPC                                          VARP.1114
   1123          IJKS=IJKNC+LWPC+1                                    VARP.1115
   1124          U(IJKS)=U(IJK)                                       VARP.1116
   1126          V(IJKS)=V(IJK)                                       VARP.1117
   1130          W(IJKS)=W(IJK)                                       VARP.1118
   1131    2201  CONTINUE                                             VARP.1119
         C        THIS SECTION TRANSFERS BOTTOM CELL TO STORAGE ARRAY VARP.1120
```

```
 VRM
    1134          DO 2203 I=2,IBP2                                             VARP.1121
    1143          KK= KK+K2NC                                                  VARP.1122
    1144          IJK=JJ+KK                                                    VARP.1123
    1146          IJKS= IJKNC+KK+1                                             VARP.1124
    1147          U(IJKS)=U(IJK)                                               VARP.1125
    1151          V(IJKS)=V(IJK)                                               VARP.1126
    1153          W(IJKS)=W(IJK)                                               VARP.1127
    1154    2203 CONTINUE                                                      VARP.1128
    1157          KK=0                                                         VARP.1129
    1157   2210   DO 2889 I=2,IBP1                                             VARP.1130
    1161          KK=KK+K2NC                                                   VARP.1131
    1163          LWPC=0                                                       VARP.1132
    1164          HRDX=.5*RDX(I)                                               VARP.1133
    1166          RDXA=1./(DX(I)+DX(I+1))                                      VARP.1134
    1171          RDXP= 1./DX(I+1)                                             VARP.1135
    1172   2220   DO 2889 K=2,KBP1                                             VARP.1136
            C ***** THE FOLLOWING CALCULATES CELL QUANTITY INDEXES             VARP.1137
    1174          LWPC=LWPC+NWPC                                               VARP.1138
    1176          HRDZ=.5*RDZ(K)                                               VARP.1139
    1200          RDZA=1./(DZ(K)+DZ(K+1))                                      VARP.1140
    1203          IJK=JJ+KK+LWPC                                               VARP.1141
    1205          IPJK=IJK+K2NC                                                VARP.1142
    1207          IJKS=IJKNC+KK+LWPC+1                                         VARP.1143
    1211          IMJK=IJKS-K2NC                                               VARP.1144
    1212          IJKP=IJK+NWPC                                                VARP.1145
    1214          IJKM=IJKS-NWPC                                               VARP.1146
    1216          IJPK=IJK+I2K2                                                VARP.1147
    1217          IJMK=IJKS                                                    VARP.1148
    1220          UR=U(IPJK)                                                   VARP.1149
    1222          UC=U(IJK)                                                    VARP.1150
    1224          UL=U(IMJK)                                                   VARP.1151
    1226          VF=V(IJPK)                                                   VARP.1152
    1230          VC=V(IJK)                                                    VARP.1153
    1232          VA=V(IJMK)                                                   VARP.1154
    1234          WT=W(IJKP)                                                   VARP.1155
    1236          WC=W(IJK)                                                    VARP.1156
    1240          WB=W(IJKM)                                                   VARP.1157
    1242          PC=P(IJK)                                                    VARP.1158
            C ***** THIS SECTION , 2300-2370 , CALCULATES U TILDE FLUXES       VARP.1159
    1254   2300   URA=.5*(UC+UR)                                               VARP.1160
    1256          ULA=.5*(UL+UC)                                               VARP.1161
    1261          VFA= .5*(VC + V(IPJK))                                       VARP.1162
    1264          VAA= .5*(VA+V(IJMK+K2NC))                                    VARP.1163
    1270          WTA= .5*(WC + W(IPJK))                                       VARP.1164
    1273          WBA= .5*(WB + W(IPJK-NWPC))                                  VARP.1165
    1300          RDZP= 1./DZ(K+1)                                             VARP.1166
            C ***** CELL CENTERED PARTIALS                                     VARP.1167
    1303          DUXR= (UR-UC) * RDXP                                         VARP.1168
    1306          DUXL= (UC-UL) *RDX(I)                                        VARP.1169
    1310          DVYF=(VF-VC) * RDYP                                          VARP.1170
    1313          DVYA= (VC-VA) * RDY(J)                                       VARP.1171
    1316          DWZT= (WT-WC) * RDZP                                         VARP.1172
    1321          DWZB= (WC-WB) * RDZ(K)                                       VARP.1173
    1323          DUYF= (U(IJPK)-UC) * RDYP                                    VARP.1174
    1326          DUYA= (UC-U(IJMK)) * RDY(J)                                  VARP.1175
    1331          DUZT= (U(IJKP)-UC) * RDZP                                    VARP.1176
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VRM
 1335        DUZB= (UC-U(IJKM)) * RDZ(K)                                         VARP.1177
 1340        DVXR= (V(IPJK)-VC) * RDXP                                           VARP.1178
 1343        DVXL= (VC-V(IMJK)) * RDX(I)                                         VARP.1179
 1346        DVZT= (V(IJKP)-VC) * RDZP                                           VARP.1180
 1352        DVZB= (VC-V(IJKM)) * RDZ(K)                                         VARP.1181
 1355        DWXR= (W(IPJK)-WC) * RDXP                                           VARP.1182
 1360        DWXL= (WC-W(IMJK)) * RDX(I)                                         VARP.1183
 1363        DWYF= (W(IJPK)-WC) * RDYP                                           VARP.1184
 1366        DWYA= (WC-W(IJMK)) * RDY(J)                                         VARP.1185
 1370        D2UX= 2.*RDXA* (DUXR-DUXL)                                          VARP.1186
 1374        D2VY= 2.*RDYA* (DVYF-DVYA)                                          VARP.1187
 1377        D2WZ= 2.*RDZA* (DWZT-DWZB)                                          VARP.1188
 1402        D2UY= 2.*RDYA* (DUYF-DUYA)                                          VARP.1189
 1405        D2UZ= 2.*RDZA* (DUZT-DUZB)                                          VARP.1190
 1410        D2VX= 2.*RDXA* (DVXR-DVXL)                                          VARP.1191
 1413        D2VZ= 2.*RDZA* (DVZT-DVZB)                                          VARP.1192
 1416        D2WX= 2.*RDXA* (DWXR-DWXL)                                          VARP.1193
 1421        D2WY= 2.*RDYA* (DWYF-DWYA)                                          VARP.1194
       C ***** TURBULENCE                                                        VARP.1195
 1424        SIGNUI= SIGNUJ= SIGNUK= NU                                          VE3.40
 1434        TBU= SIGNUI*D2UX + SIGNUJ*D2UY + SIGNUK*D2UZ                        VARP.1197
 1441        TBV= SIGNUI*D2VX + SIGNUJ*D2VY + SIGNUK*D2VZ                        VARP.1198
 1447        TBW= SIGNUI*D2WX + SIGNUJ*D2WY + SIGNUK*D2WZ                        VARP.1199
 1454        FUX=RDXA*( URA*(UC+UR) + ALX*ABS(URA)*(UC-UR)                       VARP.1200
            1         - ULA*(UL+UC) - ALX*ABS(ULA)*(UL-UC) )                     VARP.1201
 1475        FUZ=HRDZ*( WTA*(UC+U(IJKP)) + ALZ*ABS(WTA)*(UC-U(IJKP))             VARP.1202
            1         - WBA*(U(IJKM)+UC) - ALZ*ABS(WBA)*(U(IJKM)-UC) )           VARP.1203
 1515        FUY=HRDY*( VFA*(UC+U(IJPK)) + ALY*ABS(VFA)*(UC-U(IJPK))             VARP.1204
            1         - VAA*(U(IJMK)+UC) - ALY*ABS(VAA)*(U(IJMK)-UC) )           VARP.1205
       C ***** THIS SECTION , 2400-2470 , CALCULATES W TILDE FLUXES              VARP.1206
 1547  2400  UTA=.5*(UC+U(IJKP))                                                 VARP.1207
 1552        UBA= .5*(UL + U(IMJK+NWPC))                                         VARP.1208
 1556        VTA=.5*(VC+V(IJKP))                                                 VARP.1209
 1561        VATA=.5*(V(IJMK)+V(IJMK+NWPC))                                      VARP.1210
 1565        WTA=.5*(WC+WT)                                                      VARP.1211
 1567        WBA=.5*(WB+WC)                                                      VARP.1212
 1570        FWX=HRDX*( UTA*(WC+W(IJK+K2NC)) + ALX*ABS(UTA)*(WC-W(IJK+K2NC))     VARP.1213
            1         -UBA*(W(IMJK)+WC)-ALX*ABS(UBA)*(W(IMJK)-WC))               VARP.1214
 1612        FWY=HRDY*( VTA*(WC+W(IJPK)) + ALY*ABS(VTA)*(WC-W(IJPK))             VARP.1215
            1         - VATA*(W(IJMK)+WC) - ALY*ABS(VATA)*(W(IJMK)-WC) )         VARP.1216
 1632        FWZ=RDZA*( WTA*(WC+WT) + ALZ*ABS(WTA)*(WC-WT)                       VARP.1217
            1         - WBA*(WB+WC) - ALZ*ABS(WBA)*(WB-WC) )                     VARP.1218
       C ***** THIS SECTION , 2500 , CALCULATES V TILDE FLUXES.                  VARP.1219
 1662  2500  UFA=.5*(UC+U(IJPK))                                                 VARP.1220
 1664        ULFA=0.5*(UL + U(IJPK-K2NC))                                        VARP.1221
 1671        VFA=.5*(VC+VF)                                                      VARP.1222
 1672        VAA=.5*(VA+VC)                                                      VARP.1223
 1674        WFA=.5*(WC+W(IJPK))                                                 VARP.1224
 1677        WBFA=0.5*(WB + W(IJPK-NWPC))                                        VARP.1225
 1703        FVX=HRDX*( UFA*(VC+V(IPJK)) + ALX*ABS(UFA)*(VC-V(IPJK))             VARP.1226
            1         - ULFA*(V(IMJK)+VC) - ALX*ABS(ULFA)*(V(IMJK)-VC) )         VARP.1227
 1723        FVY=RDYA*( VFA*(VC+VF) + ALY*ABS(VFA)*(VC-VF)                       VARP.1228
            1         - VAA*(VA+VC) - ALY*ABS(VAA)*(VA-VC) )                     VARP.1229
 1741        FVZ=HRDZ*( WFA*(VC+V(IJKP)) + ALZ*ABS(WFA)*(VC-V(IJKP))             VARP.1230
            1         - WBFA*(V(IJKM)+VC) - ALZ*ABS(WBFA)*(V(IJKM)-VC) )         VARP.1231
       C ***** THIS SECTION , 2600 , CALCULATES FULL TILDE EQUATIONS             VARP.1232
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   1763  2600  U(IJK)=UC + DT*(2.*RDXA*(PC-P(IPJK)) + GX - FUX - FUY - FUZ)        VARP.1233
               1       +IBU*DT                                                    VARP.1234
   1777        W(IJK)=WC + DT*(2.*RDZA*(PC-P(IJKP)) + GZ - FWX - FWY - FWZ)        VARP.1235
               1 +IBW*DT                                                          VARP.1236
   2012        V(IJK)=VC + DT*(2.*RDYA*(PC-P(IJPK)) + GY - FVX - FVY - FVZ)        VARP.1237
               1 +IBV*DT                                                          VARP.1238
   2026  2700  U(IJKS)=UC                                                         VARP.1239
   2030        W(IJKS)=WC                                                         VARP.1240
   2031        V(IJKS)=VC                                                         VARP.1241
   2033  2800  CONTINUE                                                           VARP.1242
   2033  2889  CONTINUE                                                           VARP.1243
   2043        PMAX=EM6                                                           VARP.1244
         C ***** THIS SECTION, 4000-4600 , CALCULATES PRESSURES BY ITERATION      VARP.1245
   2044  4000  IFC=0                                                              VARP.1246
   2045        ASSIGN 4100 TO KBC                                                 VARP.1247
   2046        IBCF=4100                                                          VARP.1248
   2047        GO TO 1100                                                         VARP.1249
         C ***** THIS BEGINS ACTUAL PRESSURE ITERATION AFTER RETURN FROM BNDRY CNVARP.1250
   2050  4100  JJ=1                                                               VARP.1251
   2051        DO 4499 J=2,JBP1                                                   VARP.1252
   2053        JJ=JJ+I2K2                                                         VARP.1253
   2055        KK=0                                                               VARP.1254
   2056        RDYC=RDY(J)                                                        VARP.1255
   2057        RDYP=2./(DY(J)+DY(J+1))                                            VARP.1256
   2062        RDYM=2./(DY(J-1)+DY(J))                                            VARP.1257
   2065  4110  DO 4499 I=2,IBP1                                                   VARP.1258
   2067        RDXC=RDX(I)                                                        VARP.1259
   2072        RDXP=2./(DX(I)+DX(I+1))                                            VARP.1260
   2074        RDXM=2./(DX(I-1)+DX(I))                                            VARP.1261
   2077  4120  KK=KK+K2NC                                                         VARP.1262
   2101        LWPC=0                                                             VARP.1263
   2102  4130  DO 4499 K=2,KBP1                                                   VARP.1264
   2106  4140  LWPC=LWPC+NWPC                                                     VARP.1265
   2107        RDZC=RDZ(K)                                                        VARP.1266
   2110        RDZP=2./(DZ(K)+DZ(K+1))                                            VARP.1267
   2113        RDZM=2./(DZ(K-1)+DZ(K))                                            VARP.1268
   2116        IJK=JJ+KK+LWPC                                                     VARP.1269
   2120        IMJK=IJK-K2NC                                                      VARP.1270
   2122        IJMK=IJK-I2K2                                                      VARP.1271
   2123        IJKM=IJK-NWPC                                                      VARP.1272
   2125        D=RDXC*(U(IJK)-U(IMJK)) + RDYC*(V(IJK)-V(IJMK))                    VARP.1273
              1+ RDZC*(W(IJK)-W(IJKM))                                            VARP.1274
   2137        BETA=B0/(RDXC*(RDXP+RDXM) + RDYC*(RDYP+RDYM) + RDZC*(RDZP+RDZM) ) VARP.1275
   2151        DTP=-BETA*D                                                        VARP.1276
   2152        U(IJK)=U(IJK)+RDXP*DTP                                             VARP.1277
   2156        U(IMJK)=U(IMJK)-RDXM*DTP                                           VARP.1278
   2161        W(IJK)=W(IJK)+RDZP*DTP                                             VARP.1279
   2164        W(IJKM)=W(IJKM)-RDZM*DTP                                           VARP.1280
   2167        V(IJK)=V(IJK)+RDYP*DTP                                             VARP.1281
   2172        V(IJMK)=V(IJMK)-RDYM*DTP                                           VARP.1282
   2176        P(IJK)=P(IJK)+RDT*DTP                                              VARP.1283
   2201        PT=P(IJK)                                                          VARP.1284
   2201        PABS=ABS(PT)                                                       VARP.1285
   2203        PMAX=AMAX1( PMAX,PABS )                                            VARP.1286
   2207        XT=RDT*DTP/PMAX                                                    VARP.1287
   2211        PCONV=ABS(XT)                                                      VARP.1288
```

```
VRM
            C ***** THIS CHECKS FOR PRESSURE CONVERGENCE - PRESSURE CONVERGENCE      VARP.1289
   2212           IF( PCUNV.GT.CEP ) IFC=1                                           VARP.1290
   2216   4499    CONTINUE                                                           VARP.1291
   2226   4500    ITER=ITER+1                                                        VARP.1292
   2230           IF( ITER.LT.1001) GO TO 4510                                       VARP.1293
            C ***** *** ERROR 008 - PRESSURES FAILED TO CONVERGE WITHIN 1000 ITERATIVARP.1294
   2232           WRITE(VDO,2)                                                       VARP.1295
   2235           ERF=1                                                              VARP.1296
   2236           WRITE(VDO,3) PMAX                                                  VARP.1297
   2244           ASSIGN 99999 TO KPRT                                               VARP.1298
   2245           GO TO 6020                                                         VARP.1299
            C ***** THIS CHECKS TO SEE IF ANY PRESSURES FAILED TO CONVERGED          VARP.1300
   2246   4510    IF( IFC.EQ.1 ) GO TO 4000                                          VARP.1301
   2250           ASSIGN 5500 TO KBC                                                 VARP.1302
   2251           IBCF=5500                                                          VARP.1303
   2252           TIMET= TIMET+DT                                                    VARP.1304
   2254           NCYC= NCYC+1                                                       VARP.1305
   2256           IF(TIMET.LT.TPLT) GO TO 1100                                       VARP.1306
   2260           IPLTF=1                                                            VARP.1307
   2261           CALL VRIO                                                          VARP.1308
   2262           TPLT= TPLT+TPL                                                     VARP.1309
   2264           GO TO 1100                                                         VARP.1310
            C ***** THIS SECTION , 5500 , CALLS THE VARIABLE REST. PARTICLE SECTION.VARP.1311
   2265   5500    IF( NPMX.LT.1 ) GO TO 5900                                         VARP.1312
   2270           CALL VRPS                                                          VARP.1313
   2271           IF(IPARIF.LT.1) GO TO 5900                                         VARP.1314
            C  INCREMENT WHEN HYDRO IS BYPASSED                                     VARP.1315
   2274           TIMET= TIMET + DT                                                  VARP.1316
   2275           NCYC= NCYC+1                                                       VARP.1317
   2277           IF( TIMET.LT.TPLT) GO TO 5900                                      VARP.1318
   2302           IPLTF= 1                                                           VARP.1319
   2303           CALL VRIO                                                          VARP.1320
   2304           TPLT= TPLT+TPL                                                     VARP.1321
            C ***** THIS SECTION , 5900 , UPDATES TIME AND NUMBER OF CYCLES          VARP.1322
   2306    5900 CALL SECOND(S2)                                                      VARP.1323
   2310           GRIND=(S2-S1)*RIHJKH                                               VARP.1324
   2313           WRITE(6,5) GRIND,TIMET                                             VARP.1325
   2323           WRITE(VDO,4) TIMET,ITER                                            VARP.1326
   2333           IF( IPARIF.GT.0) GO TO 7000                                        VARP.1327
            C ***** THIS SECTION , 6000 , CALLS THE VARIABLE RESISTANCE INPUT/OUTPUTVARP.1328
   2336   6000    IF( TIMET.GE.TPRT ) GO TO 6015                                     VARP.1329
   2341           GO TO 7000                                                         VARP.1330
   2341   6015    TPRT=TPRT+TPR                                                      VARP.1331
   2343           IPLTF=0                                                            VARP.1332
   2344   6020    CALL VRIO                                                          VARP.1333
   2345           GO TO KPRT,( 1100,2030,4000,7000,99999 )                           VARP.1334
            C ***** THIS SECTION , 7000-7200 , HANDLES MAG TAPE WRITES               VARP.1335
   2350   7000    ASSIGN 1000 TO KID                                                 VARP.1336
   2351           IF( TIMET.LT.TFIN ) GO TO 7020                                     VARP.1337
   2354           ASSIGN 8000 TO KTD                                                 VARP.1338
   2355           IF( TWTD.LT.1.E+5 ) GO TO 7100                                     VARP.1339
   2357           RETURN                                                             VARP.1340
   2360   7020    IF( TIMET.LT.TWTD ) GO TO 1000                                     VARP.1341
   2363   7030    TWTD=TWTD+TTD                                                      VARP.1342
   2365   7100    TD=TD+1                                                            VARP.1343
   2367   7200    CALL VRTAP                                                         VARP.1344
```

```
VHM
   2370         IF( ERF.EQ.1 ) GO TO 99999                                         VARP.1345
   2372         GO TO KID,( 1000,1100,8000 )                                       VARP.1346
          C ***** THIS SECTION , 7500 , HANDLES MAG TAPE RESTART                   VARP.1347
   2375    7500 ASSIGN 1000 TO KID                                                 VARP.1348
   2376         GO TO 7200                                                         VARP.1349
   2377    8000 CONTINUE                                                           VARP.1350
   2377   99999 RETURN                                                             VARP.1351
   2400         END                                                                VARP.1352


SUBPROGRAM LENGTH

03071

FUNCTION ASSIGNMENTS

STATEMENT ASSIGNMENTS
1      - 002404   2      - 002413   3      - 002425   4      - 002431   5      - 002436   900    - 000006
1000   - 000023   1040   - 000031   1100   - 000032   1140   - 000070   1150   - 000103   1160   - 000111
1180   - 000114   1240   - 000123   1250   - 000134   1260   - 000142   1280   - 000146   1289   - 000146
1300   - 000153   1340   - 000211   1350   - 000222   1360   - 000230   1380   - 000234   1400   - 000234
1440   - 000243   1450   - 000254   1460   - 000262   1480   - 000265   1489   - 000265   1500   - 000272
1540   - 000330   1550   - 000341   1560   - 000347   1580   - 000353   1600   - 000353   1640   - 000362
1650   - 000373   1660   - 000401   1680   - 000404   1689   - 000404   1700   - 000411   1701   - 000446
1702   - 000455   1703   - 000463   1704   - 000472   1705   - 000500   1706   - 000506   1707   - 000513
1708   - 000521   1709   - 000526   1710   - 000535   1711   - 000543   1712   - 000551   1713   - 000556
1720   - 000566   1721   - 000640   1722   - 000653   1724   - 000660   1726   - 000666   1728   - 000674
1730   - 000704   1732   - 000712   1733   - 000720   1734   - 000723   1736   - 000726   1738   - 000731
1740   - 000734   1742   - 000737   1745   - 000742   1746   - 000746   1747   - 000752   1748   - 000756
1749   - 000762   1750   - 000766   1751   - 000771   1752   - 000775   1753   - 001000   1754   - 001004
1755   - 001010   1756   - 001014   1759   - 001017   1760   - 001017   1770   - 001022   1930   - 001022
2000   - 001025   2010   - 001031   2020   - 001036   2030   - 001037   2100   - 001040   2200   - 001074
2210   - 001160   2220   - 001173   2300   - 001245   2400   - 001537   2500   - 001651   2600   - 001763
2700   - 002026   2800   - 002034   2889   - 002034   4000   - 002045   4100   - 002051   4110   - 002056
4120   - 002100   4130   - 002103   4140   - 002105   4499   - 002217   4500   - 002227   4510   - 002247
5500   - 002266   5900   - 002307   6000   - 002337   6015   - 002342   6020   - 002345   7000   - 002351
7020   - 002361   7030   - 002364   7100   - 002366   7200   - 002370   7500   - 002376   8000   - 002400
99999  - 002400

BLOCK NAMES AND LENGTHS
VRCOM  - 106240/01  CONCEN - 000132/02  AMIX   - 001130/03  FL     - 000035/04  FLS    - 000011/05  VRCON  - 006352/06
MODSET - 000310/07  SAFLM  - 000447/08  ZLAST  - 000001/11

VARIABLE ASSIGNMENTS
A      - 000000/01  ALX    - 000000/06  ALY    - 000001/06  ALZ    - 000002/06  BETA   - 003061     BKGS   - 000056/02
BUFL   - 000064/06  B0     - 000003/06  C      - 000000/03  CEP    - 000005/06  CPRT   - 002653     CU     - 000064/01
COF    - 000005/01  D      - 003060     D1     - 000006/06  DTP    - 003062     DUXL   - 002770     DUXR   - 002767
DUYA   - 002776     DUYF   - 002775     DUZB   - 003000     DUZT   - 002777     DVXL   - 003002     DVXR   - 003001
DVYA   - 002772     DVYF   - 002771     DVZB   - 003004     DVZT   - 003003     DWXL   - 003006     DWXR   - 003005
DWYA   - 003010     DWYF   - 003007     DWZB   - 002774     DWZT   - 002773     DX     - 000007/06  DY     - 000130/06
DZ     - 000251/06  D2UX   - 003011     D2UY   - 003014     D2UZ   - 003015     D2VX   - 003016     D2VY   - 003012
D2VZ   - 003017     D2WX   - 003020     D2WY   - 003021     D2WZ   - 003013     EM6    - 000373/06  EWF    - 000374/06
F      - 002650     FACS   - 000050/02  FB     - 000024/04  FFX3   - 000021/08  FFY3   - 000134/08  FI     - 000000/05
FM     - 000034/04  FO     - 000000/04  FUX    - 003030     FUY    - 003032     FUZ    - 003031     FVX    - 003046
FVY    - 003047     FVZ    - 003050     FWX    - 003037     FWY    - 003040     FWZ    - 003041     GRIND  - 003067
```

```
          SUBROUTINE FILMCO                                                 VARP.528
          INTEGER E,ERF,VDI,VDO,BUFL,PYML,PXML,CPRT,VNTP,VTP,PF,TD,TD1,TD2, INREAL.2
         1 PRFLM,COF,SHIFT,OBLOC,OBTYP,FI,FO,FB,FM,OBTYPL                   INREAL.3
          REAL NU                                                           INREAL.4
      C                                                                     INREAL.5
          DIMENSION U(1),V(1),W(1),P(1),CO(1),COF(1)                        DIMEN.2
         1 ,VOL(1)                                                          DIMEN.3
          DIMENSION SPEC(10),TSP(10)                                        VF3.1
          DIMENSION TA(1),OCON(1)                                           DIMEN.6
      C                                                                     DIMEN.7
          COMMON/VRCOM/A(36000)                                             VF3.2
          COMMON/CONCEN/ NSPS(10),PMAXMS(10),PMINMS(10),BKGS(10),FACS(10)   VF3.3
         1 ,IPEDIT(10),IPFL(10),IPES(10),PMIN(10)                           VF3.4
          COMMON /AMIX/ C(600)                                              COMM.5
          COMMON/FL/FO(20),FB(8),FM                                         COMM.6
          COMMON/FLS/FI(9)                                                  COMM.7
          COMMON/VRCON/ALX,ALY,ALZ,BO,BUFL,CEP,DT,DX(80),DXC,DY(80),DYC,    VF3.5
         1 DZ(80),DZC,EM0,EM6,ERF,GPX,GPY,GPZ,GX,GY,GZ,IBP1,IBP2,IBR,IBRED, VF3.6
         2 IBRIN,IBRST,IGOP(6),IJKMX,IJKNC,IJK2,IJP1K,IPL,IPR,ITER,I2JK2,   COMM.10
         * IKP2,IPARIF,IPLTF,ISFLG,RIBJBKB,LPR,DROU,                        COMM.11
         *IJKCON,ICON,JCON,                                                 COMM.12
         3 I2K2,JBP1,JBP2,JBR,JBRED,JBRIN,JBRST,JNC,JPA,JPE,J2NC,KBP1,KBP2, COMM.13
         4 KBR,KBRED,KBRIN,KBRST,KFP,KNC,KPB,KPT,KWA,KWB,KWF,KWL,KWR,KWT,   COMM.14
         5 K2NC,LABEL(8),LNPART,LNVRCM,LPARTC,NCTP,NCVTP(6),NCYC,NGOP,NOPI, COMM.15
         *NOCONC,                                                           COMM.16
         * OBLOC(1200),OBTYP(1200),NOB,NU,                                  VF3.7
         6 NOVP,NOVS,NPMX,NPRT,NTPE,NWPC,NWPP,PDX,PDY,PDZ,PI,PRFLM,RDT,     COMM.18
         7 RDX(80),RDY(80),RDZ(80),RRAN(20),SIGMA,TD,TD1,TD2,TFIN,TIMET,TIP,VF3.8
         8 TPL,TPLT,TPR,TPRT,TTD,TWIP,TWTD,UI,UPI,VDI,VDO,VI,VNTP(6),VPI,   COMM.20
         9 VTP,WI,WPI,WRAN(20),X(80),XPCEN,Y(80),YPCEN,Z(80),ZPCEN          VF3.9
          COMMON /MODSET/ SCFLM(200)                                        COMM.22
          COMMON /SAFLM/ XCONV,ZCONV,FX1,FX2,FX3,FX4,FY1,FY2,FY3,FY4,       COMM.23
         1 FXL,FYB,PXL,PYB,IFLB(3),FFX3(75),FFY3(75)                        COMM.24
         2 ,ITCYC(3),XFC1(4),XFC2(4),YFC1(4),YFC2(4),PBTIM(2),XML,YML,ZML   COMM.25
         3 ,IFMID,IFIFST,IPLOPT,IPM(20),IPMM,IPPP,IPROJ,JPM(20),JPMM,JPPP,  COMM.26
         4 KPM(20),KPMM,KPPP,NEC,NMC,NPS,NPV,PEC(10),PMC(10),YCONV          COMM.27
         5 ,IFLAB,IFLIN,IFPNT,IFOPT,NCH,XFSP,XT,YFSP,YT                     COMM.28
          COMMON /ZLAST/ ZLAS                                               COMM.29
      C                                                                     COMM.30
          EQUIVALENCE (A(1),U),(A(2),V),(A(3),W),(A(4),P),(A(5),CO),        EQUIV.2
         1 (A(6),COF), (A(7),VOL)                                           EQUIV.3
          EQUIVALENCE (C(1),TA,OCON)                                        EQUIV.7
      C                                                                     EQUIV.8
      100 IF( PRFLM.LT.1 ) RETURN                                           VARP.533
    4     DM1=1./AMAX1(XML,ZML)                                             VARP.534
   11     DM2=1./AMAX1(XML,YML)                                             VARP.535
   14     DM3=1./AMAX1(YML,ZML)                                             VARP.536
   17     XFSP=0.363                                                        VARP.537
   21     YFSP=0.030                                                        VARP.538
   23     I1=J1=K1=2                                                        VARP.539
   26     I2=IBP2                                                           VARP.540
   27     J2=JBP2                                                           VARP.541
   30     K2=KBP2                                                           VARP.542
   32     I3=J3=K3=1                                                        VARP.543
   35     RETURN                                                            VARP.544
      C ***** THIS ENTRY , 200 , COMPUTES FILM PLANE COORDINATES.           VARP.545
```

```
FILMCO
    36          ENTRY FPLAN                                                        VARP.546
    43      200 GO TO( 220,230,240 ),IPLOPT                                         VARP.547
          C ***** THIS SECTION , 220 , COMPUTES CONSTANTS FOR PLANE I X K.          VARP.548
    52      220 DM=DM1                                                             VARP.549
    53          XM=XML                                                             VARP.550
    55          YM=ZML                                                             VARP.551
    57          FXL=PXL=X(1)                                                       VARP.552
    61          FYB=PYB=Z(1)                                                       VARP.553
    64          GO TO 260                                                          VARP.554
          C ***** THIS SECTION , 230 , COMPUTES CONSTANTS FOR PLANE I X J.          VARP.555
    64      230 DM=DM2                                                             VARP.556
    65          XM=XML                                                             VARP.557
    67          YM=YML                                                             VARP.558
    71          FXL=PXL=X(1)                                                       VARP.559
    73          FYB=PYB=Y(1)                                                       VARP.560
    76          GO TO 260                                                          VARP.561
          C ***** THIS SECTION , 240 , COMPUTES CONSTANTS FOR PLANE J X K.          VARP.562
    76      240 DM=DM3                                                             VARP.563
    77          XM=YML                                                             VARP.564
   101          YM=ZML                                                             VARP.565
   103          FXL=PXL=Y(1)                                                       VARP.566
   105          FYB=PYB=Z(1)                                                       VARP.567
   111      260 XFEP=XM*DM+XFSP-0.060                                              VARP.568
   114          YFEP=YM*DM+YFSP-0.060                                              VARP.569
   117          XCONV=(XFEP-XFSP)/XM                                               VARP.570
   121          YCONV=(YFEP-YFSP)/YM                                               VARP.571
   123          XFC1(1)=XFSP                                                       VARP.572
   124          XFC1(2)=XFEP                                                       VARP.573
   125          XFC1(3)=XFEP                                                       VARP.574
   126          XFC1(4)=XFSP                                                       VARP.575
   127          YFC1(1)=YFSP                                                       VARP.576
   131          YFC1(2)=YFSP                                                       VARP.577
   131          YFC1(3)=YFEP                                                       VARP.578
   133          YFC1(4)=YFEP                                                       VARP.579
   133          XFC2(1)=XFEP                                                       VARP.580
   134          XFC2(2)=XFEP                                                       VARP.581
   135          XFC2(3)=XFSP                                                       VARP.582
   136          XFC2(4)=XFSP                                                       VARP.583
   137          YFC2(1)=YFSP                                                       VARP.584
   140          YFC2(2)=YFEP                                                       VARP.585
   141          YFC2(3)=YFEP                                                       VARP.586
   142          YFC2(4)=YFSP                                                       VARP.587
   144          RETURN                                                             VARP.588
          C ***** THIS ENTRY FCTEST TEST ON FILM COORDINATES OUT OF RANGE.          VARP.589
   144          ENTRY FCTEST                                                       VARP.590
   151          IF( FX1.LT.XFSP ) FX1=XFSP                                         VARP.591
   154          IF( FX1.GT.XFEP ) FX1=XFEP                                         VARP.592
   157          IF( FY1.LT.YFSP ) FY1=YFSP                                         VARP.593
   162          IF( FY1.GT.YFEP ) FY1=YFEP                                         VARP.594
   165          IF( IFTEST.LT.2 ) RETURN                                           VARP.595
   170          IF( FX2.LT.XFSP ) FX2=XFSP                                         VARP.596
   173          IF( FX2.GT.XFEP ) FX2=XFEP                                         VARP.597
   176          IF( FY2.LT.YFSP ) FY2=YFSP                                         VARP.598
   201          IF( FY2.GT.YFEP ) FY2=YFEP                                         VARP.599
   204          IF( IFTEST.LT.3 ) RETURN                                           VARP.600
   207          IF( FX3.LT.XFSP ) FX3=XFSP                                         VARP.601
```

```
  FILMCO
      212         IF( FX3.GT.XFEP ) FX3=XFEP                                      VARP.602
      215         IF( FY3.LT.YFSP ) FY3=YFSP                                      VARP.603
      220         IF( FY3.GT.YFEP ) FY3=YFEP                                      VARP.604
      223         IF( FX4.LT.XFSP ) FX4=XFSP                                      VARP.605
      226         IF( FX4.GT.XFEP ) FX4=XFEP                                      VARP.606
      231         IF( FY4.LT.YFSP ) FY4=YFSP                                      VARP.607
      234         IF( FY4.GT.YFEP ) FY4=YFEP                                      VARP.608
      237         RETURN                                                          VARP.609
            C ***** THIS ENTRY FLMID LABELS SAI,DATE, TIME+CYCLE, AND DRAWS FRAME.  VARP.610
      240         ENTRY FLMID                                                     VARP.611
      245         IFOPT=1                                                         VARP.612
      246         CALL FLMOPT                                                     VARP.613
      247         IFLAB=1                                                         VARP.614
      250         CALL FLMLAB                                                     VARP.615
      251         IFOPT=2                                                         VARP.616
      252         CALL FLMOPT                                                     VARP.617
      253         XT=0.02                                                         VARP.618
      255         ENCODE(30,9000,ITCYC) TIMET,NCYC                                VARP.619
      266         NCH=30                                                          VARP.620
      267         IFLAB=3                                                         VARP.621
      270         CALL FLMLAB                                                     VARP.622
      271         IFLAB=2                                                         VARP.623
      272         IF( IFMID.GT.0 ) RETURN                                         VARP.624
      274         IFLIN=1                                                         VARP.625
      275         CALL FLMLIN                                                     VARP.626
      276         RETURN                                                          VARP.627
            C ***** FORMATS ***** FORMATS ***** FORMATS ***** FORMATS ***** FORMATS,VARP.628
            9000  FORMAT(6HTIME =,1PE11.4,8H CYCLE =,I5)                          VARP.629
      277         END                                                             VARP.630


  SUBPROGRAM LENGTH

  00403

  FUNCTION ASSIGNMENTS

  STATEMENT ASSIGNMENTS
  100    - 000002    200    - 000044    220    - 000053    230    - 000065    240    - 000077    260    - 000111
  9000   - 000310

  BLOCK NAMES AND LENGTHS
  VRCOM  - 106240/01  CONCFN - 000132/02  AMIX   - 001130/03  FL     - 000035/04  FLS    - 000011/05  VRCON  - 006352/06
  MODSET - 000310/07  SAFLM  - 000447/08  ZLAST  - 000001/11

  VARIABLE ASSIGNMENTS
  A      - 000000/01  BKGS   - 000036/02  BUFL   - 000004/06  C      - 000000/03  CPRT   - 000332     CO     - 000004/01
  CRF    - 000005/01  DM     - 000376     DM1    - 000362     DM2    - 000363     DM3    - 000364     DX     - 000067/06
  DY     - 000130/06  DZ     - 000251/06  ERF    - 000374/06  F      - 000327     FACS   - 000050/02  FB     - 000024/04
  FCTEST - 000326     FFX3   - 000021/08  FFY3   - 000134/08  FI     - 000000/05  FLMID  - 000326     FM     - 000034/04
  FO     - 000000/04  FPLAN  - 000326     FXL    - 000012/08  FX1    - 000002/08  FX2    - 000003/08  FX3    - 000004/08
  FX4    - 000005/08  FYB    - 000013/08  FY1    - 000006/08  FY2    - 000007/08  FY3    - 000010/08  FY4    - 000011/08
  IBP2   - 000404/06  IFLAB  - 000436/08  IFLB   - 000016/08  IFLIN  - 000437/08  IFMID  - 000277/08  IFOPT  - 000441/08
  IFTEST - 000300/08  IGOP   - 000411/06  IPEDIT - 000062/02  IPEL   - 000074/02  IPES   - 000106/02  IPLOPT - 000301/08
  IPM    - 000302/08  ITCYC  - 000247/08  I1     - 000365     I2     - 000370     I3     - 000373     JBP2   - 000443/06
```

```
          SUBROUTINE FLMCAL                                                   VARP.631
          INTEGER F,ERE,VDI,VDO,BUFL,PYML,PXML,CPRT,VNTP,VTP,PF,TD,TD1,TD2,  INREAL.2
         1 PHFLM,COF,SHIFT,OBLOC,OBTYP,FI,FO,FB,FM,OBTYPL                     INREAL.3
          REAL NU                                                             INREAL.4
    C                                                                         INREAL.5
          DIMENSION U(1),V(1),W(1),P(1),CQ(1),COF(1)                          DIMEN.2
         1 ,VOL(1)                                                            DIMEN.3
          DIMENSION SPEC(10),TSP(10)                                          VE3.1
          DIMENSION TA(1),QCON(1)                                             DIMEN.6
    C                                                                         DIMEN.7
          COMMON/VRCOM/A(36000)                                               VE3.2
          COMMON/CONCEN/ NSPS(10),PMAXWS(10),PMINWS(10),BKGS(10),FACS(10)    VF3.3
         1 ,IPEDIT(10),IPEL(10),IPES(10),PMIN(10)                             VF3.4
          COMMON /AMIX/ C(600)                                                COMM.5
          COMMON/FL/FO(20),FB(8),FM                                           COMM.6
          COMMON/FLS/FI(9)                                                    COMM.7
          COMMON/VRCON/ALX,ALY,ALZ,BO,BUFL,CEP,DT,DX(80),DXC,DY(80),DYC,      VE3.5
         1 DZ(80),DZC,EM0,EM6,ERF,GPX,GPY,GPZ,GX,GY,GZ,IBP1,IBP2,IPR,IBRED,  VF3.6
         2 IBRIN,IBRST,IGOP(6),IJKMX,IJKNC,IJK2,IJP1K,IPL,IPH,ITER,I2JK2,    COMM.10
         * IKP2,IPARTE,IPLIE,ISELG,RIBJBKB,LPR,DROU,                          COMM.11
         *IJKCON,ICON,JCON,                                                   COMM.12
         3 I2K2,JBP1,JBP2,JBR,JBRED,JBRIN,JBRST,JNC,JPA,JPF,J2NC,KBP1,KBP2,  COMM.13
         4 KBR,KBRED,KBRIN,KBRST,KFP,KNC,KPH,KPT,KWA,KWB,KWF,KWL,KWR,KWT,    COMM.14
         5 K2NC,LABEL(8),LNPART,LNVRCM,LPARTC,NCTP,NCVTP(6),NCYC,NGOP,NOPI,  COMM.15
         *NUCONC,                                                             COMM.16
         * OBLOC(1200),OBTYP(1200),NOB,NU,                                    VF3.7
         6 NOVP,NOVS,NPMX,NPRT,NTPE,NWPC,NWPP,PDX,PDY,PDZ,PI,PHFLM,RD1,      COMM.18
         7 RDX(80),RDY(80),RDZ(80),RRAN(20),SIGMA,TD,TD1,TD2,TFIN,TIMET,TIP,VE3.8
         8 TPL,TPLT,TPR,TPRT,TTD,TWIP,TWTD,UI,UPI,VDI,VDU,VT,VNTP(6),VPI,    COMM.20
         9 VTP,WI,WPI,WRAN(20),X(80),XPCEN,Y(80),YPCEN,Z(80),ZPCEN            VF3.9
          COMMON /MODSET/ SCFLM(200)                                          COMM.22
          COMMON /SAFLM/ XCONV,ZCONV,FX1,FX2,FX3,FX4,FY1,FY2,FY3,FY4,         COMM.23
         1 FXL,FYH,PXL,PYH,IFLB(3),FFX3(75),FFY3(75)                          COMM.24
         2 ,ITCYC(3),XFC1(4),XFC2(4),YFC1(4),YFC2(4),PBTIM(2),XML,YML,ZML    COMM.25
         3 ,IFMID,IFTEST,IPLOPT,IPM(20),IPMM,IPPP,IPWOJ,JPM(20),JPMM,JPPP,   COMM.26
         4 KPM(20),KPMM,XPPP,NEC,NMC,NPS,NPV,PEC(10),PMC(10),YCONV           COMM.27
         5 ,IFLAB,IFLIN,IFPNT,IFOPT,NCH,XFSP,XT,YFSP,YT                       COMM.28
          COMMON //LAST/ ZLAS                                                 COMM.29
    C                                                                         COMM.30
          EQUIVALENCE (A(1),U),(A(2),V),(A(3),W),(A(4),P),(A(5),CQ),          EQUIV.2
         1 (A(6),COF), (A(7),VOL)                                             EQUIV.3
          EQUIVALENCE (C(1),TA,QCON)                                          EQUIV.7
    C                                                                         EQUIV.8
          DATA ISAI/10H    SAI     /                                          VARP.636
    C ***** THIS ENTRY ADVANCES TO A NEW FILM FRAME.                          VARP.637
          ENTRY FLMADV                                                        VARP.638
    C ***** BKY SC 4060 RECORDS THE DISPLAY AND FILM ADVANCE.                 VARP.639
 6     120 CALL PAGEG(SCFLM,0,1,1)                                            VARP.640
11     190 RETURN                                                             VARP.641
    C ***** THIS ENTRY TERMINATES THE FILM PLOT PACKAGE.                      VARP.642
12        ENTRY FLMFIN                                                        VARP.643
    C ***** BKY SC 4060 TERMINATES GRAPHIC OUTPUT.                            VARP.644
17     220 CALL EXITG(SCFLM)                                                  VARP.645
21     290 RETURN                                                             VARP.646
    C ***** THIS ENTRY INITIALIZES THE FILM PLOT PACKAGE.                     VARP.647
22        ENTRY FLMINIT                                                       VARP.648
```

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    FLMCAL
        27           IFIAP=10                                                                  VARP.649
             C ***** BKY SC 4060 INITIALIZE THE GRAPHICS SYSTEM.                               VARP.650
        30     320   CALL MODFSG(SCFLM,IFTAP)                                                  VARP.651
        32           CALL OBJCTG(SCFLM,0.,0.,1.333,1.)                                         VARP.652
        36           CALL SUBJEG(SCFLM,0.,0.,1.333,1.)                                         VARP.653
        42     390   RETURN                                                                    VARP.654
             C ***** THIS ENTRY LABELS THE FILM FRAME.                                         VARP.655
        43           ENTRY FLMLAB                                                              VARP.656
             C ***** BKY SC 4060 CHARACTER DISPLAY.                                            VARP.657
        50     420   GO TO( 422,424,426 ),IFLAB                                                VARP.658
        57     422   YT=0.70                                                                   VARP.659
        60           XT=0.12                                                                   VARP.660
        62           CALL LEGNDG(SCFLM,XT,YT,10,ISAI)                                          VARP.661
        66           YT=YT-0.08                                                                VARP.662
        70           CALL LEGNDG(SCFLM,XT,YT,10,PBTIM(1))                                      VARP.663
        74           YT=0.60                                                                   VARP.664
        76           GO TO 490                                                                 VARP.665
        76     424   CALL LEGNDG(SCFLM,XT,YT,NCH,IFLB)                                         VARP.666
       102           GO TO 490                                                                 VARP.667
       103     426   CALL LEGNDG(SCFLM,XT,YT,NCH,ITCYC)                                        VARP.668
       107     490   RETURN                                                                    VARP.669
             C ***** THIS ENTRY DRAWS LINE SEGMENTS.                                           VARP.670
       110           ENTRY FLMLIN                                                              VARP.671
             C ***** BKY SC 4060 DRAWS NONCONTIGUOUS LINE SEGMENTS.                            VARP.672
       115     520   GO TO( 522,524,526,528,530,532 ),IFLIN                                    VARP.673
       127     522   CALL SEGMTG(SCFLM,4,XFC1,YFC1,XFC2,YFC2)                                  VARP.674
       133           CALL SEGMTG(SCFLM,4,XFC1,YFC1,XFC2,YFC2)                                  VARP.675
       137           GO TO 590                                                                 VARP.676
       140     524   CALL SEGMTG(SCFLM,1,FX1,FY1,FX2,FY2)                                      VARP.677
       144           GO TO 590                                                                 VARP.678
       145     526   CALL SEGMTG(SCFLM,1,FX2,FY2,FX3,FY3)                                      VARP.679
       151           GO TO 590                                                                 VARP.680
       152     528   CALL SEGMTG(SCFLM,1,FX3,FY3,FX4,FY4)                                      VARP.681
       156           GO TO 590                                                                 VARP.682
       157     530   CALL SEGMTG(SCFLM,1,FX4,FY4,FX1,FY1)                                      VARP.683
       163           GO TO 590                                                                 VARP.684
       164     532   CALL SEGMTG(SCFLM,1,FX2,FY2,FX1,FY1)                                      VARP.685
       170     590   RETURN                                                                    VARP.686
             C ***** THIS ENTRY PLOTS AN ARRAY OF POINTS.                                      VARP.687
       171           ENTRY FLMPNT                                                              VARP.688
             C ***** BKY SC 4060 PLOTS POINTS.                                                 VARP.689
       176     620   GO TO( 622,624 ),IFPNT                                                    VARP.690
       204     622   CALL POINTG(SCFLM,1,FX1,FY1)                                              VARP.691
       207           GO TO 690                                                                 VARP.692
       210     624   CALL POINTG(SCFLM,1,FX2,FY2)                                              VARP.693
       213     690   RETURN                                                                    VARP.694
             C ***** THIS ENTRY COMPUTES GRAPHICS SYSTEM OPTIONS.                              VARP.695
       214           ENTRY FLMOPT                                                              VARP.696
             C ***** BKY SC 4060 SYSTEMS OPTIONS.                                              VARP.697
       221     720   GO TO( 721,722,723,724,725,726,727,728 ),IFOPT                            VARP.698
             C ***** BKY SC 4060 LARGE CHARACTER SIZE.                                         VARP.699
       235     721   CALL SETSMG(SCFLM,45,1.5)                                                 VARP.700
       240           GO TO 790                                                                 VARP.701
             C ***** BKY SC 4060 NORMAL CHARACTER SIZE.                                        VARP.702
       241     722   CALL SETSMG(SCFLM,45,1.0)                                                 VARP.703
       244           GO TO 790                                                                 VARP.704
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FLMCAL
            C ***** BKY SC 4060 RESETS NORMAL PLOT POINT.                                      VARP.705
      245     723 CALL SETSMG(SCFLM,84,0.0)                                                    VARP.706
      250           GO TO 790                                                                  VARP.707
            C ***** BKY SC 4060 RESETS NORMAL LINE WIDTH.                                      VARP.708
      251     724 CALL SETSMG(SCFLM,30,1.0)                                                    VARP.709
      254           GO TO 790                                                                  VARP.710
            C ***** BKY SC 4060 RESETS NORMAL LINE DENSITY.                                    VARP.711
      255     725 CALL SETSMG(SCFLM,94,0.0)                                                    VARP.712
      260           GO TO 790                                                                  VARP.713
            C ***** BKY SC 4060 RESETS UPPER CHARACTER CASE.                                   VARP.714
      261     726 CALL SETSMG(SCFLM,55,0.0)                                                    VARP.715
      264           GO TO 790                                                                  VARP.716
            C ***** BKY SC 4060 RESETS L=LOW FOR PLOT POINT.                                   VARP.717
      265     727 CALL SETSMG(SCFLM,84,1HL)                                                    VARP.718
      270           GO TO 790                                                                  VARP.719
            C ***** BKY SC 4060 RESETS H=HIGH FOR PLOT POINT.                                  VARP.720
      271     728 CALL SETSMG(SCFLM,84,1HH)                                                    VARP.721
      274     790 RETURN                                                                       VARP.722
      275           END                                                                        VARP.723


   SUBPROGRAM LENGTH

   00375

   FUNCTION ASSIGNMENTS

   STATEMENT ASSIGNMENTS
   120    - 000007    190    - 000012    220    - 000020    240    - 000022    320    - 000031    390    - 000043
   420    - 000051    422    - 000060    424    - 000077    426    - 000104    490    - 000110    520    - 000116
   522    - 000130    524    - 000141    526    - 000146    528    - 000153    530    - 000160    532    - 000165
   590    - 000171    620    - 000177    622    - 000205    624    - 000211    690    - 000214    720    - 000222
   721    - 000236    722    - 000242    723    - 000246    724    - 000252    725    - 000256    726    - 000262
   727    - 000266    728    - 000272    790    - 000275

   BLOCK NAMES AND LENGTHS
   VRCOM  - 106240/01  CONCEN - 000132/02  AMIX   - 001130/03  FL     - 000035/04  FLS    - 000011/05  VRCON  - 006352/06
   MODSET - 000310/07  SAFLM  - 000447/08  ZLAST  - 000001/11

   VARIABLE ASSIGNMENTS
   A      - 000000/01  BKGS   - 000036/02  BUFL   - 000004/06  C      - 000000/03  CPRT   - 000343     CU     - 000004/01
   COF.   - 000005/01  DX     - 000007/06  DY     - 000130/06  DZ     - 000251/06  FRF    - 000374/06  F      - 000340
   FACS   - 000050/02  FB     - 000024/04  FFX3   - 000021/08  FFY3   - 000134/08  FI     - 000000/05  FLMADV - 000337
   FLMFIN - 000337     FLMINIT- 000337     FLMLAB - 000337     FLMLIN - 000337     FLMOPT - 000337     FLMPNT - 000337
   FM     - 000034/04  FO     - 000000/04  FX1    - 000002/08  FX2    - 000003/08  FX3    - 000004/08  FX4    - 000005/08
   FY1    - 000006/08  FY2    - 000007/08  FY3    - 000010/08  FY4    - 000011/08  IFLAB  - 000436/08  IFLB   - 000016/08
   IFLIN  - 000437/08  IFOPT  - 000441/08  IFPNT  - 000440/08  IFTAP  - 000374     IGOP   - 000411/06  IPEDIT - 000062/02
   IPEL   - 000074/02  IPES   - 000106/02  IPM    - 000302/08  ISAI   - 000373     IICYC  - 000247/08  JPM    - 000331/08
   KPM    - 000357/08  LABEL  - 000475/06  NCH    - 000442/08  NCVIP  - 000511/06  NSPS   - 000000/02  NU     - 005264/06
   OBLOC  - 000523/06  OBTYP  - 003003/06  OBTYPL - 000346     P      - 000003/01  PBTIM  - 000272/08  PFC    - 000411/08
   PF     - 000344     PMAXWS - 000012/02  PMC    - 000423/08  PMIN   - 000120/02  PMINWS - 000024/02  PRFLM  - 005300/06
   PXML   - 000342     PYML   - 000341     QCON   - 000000/03  RDX    - 005302/06  RDY    - 005422/06  RDZ    - 005542/06
   RRAN   - 005662/06  SCFLM  - 000000/07  SHIFT  - 000345     SPEC   - 000347     TA     - 000000/03  TD     - 005707/06
   TD1    - 005710/06  TD2    - 005711/06  TSP    - 000361     U      - 000000/01  V      - 000001/01  VDT    - 005726/06
   VDO    - 005727/06  VNTP   - 005731/06  VOL    - 000006/01  VTP    - 005740/06  W      - 000002/01  WRAN   - 005743/06
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      SUBROUTINE VRPS                                                   VARP.1353
      LARGE XPC(1),YPC(1),ZPC(1), PM(1),ARC(29996),CON(15000)           VF3.43
      INTEGER F,ERF,VDI,VDU,BUFL,PYML,PXML,CPRT,VNIP,VIP,PF,TD,TD1,TD2, INREAL.2
     1 PRFLM,CQE,SHIFT,OBLOC,OBTYP,FI,FO,FB,FM,OBTYPL                   INREAL.3
      REAL NU                                                           INREAL.4
C                                                                       INREAL.5
      DIMENSION U(1),V(1),W(1),P(1),CQ(1),CQE(1)                        DIMEN.2
     1 ,VOL(1)                                                          DIMEN.3
      DIMENSION SPEC(10),TSP(10)                                        VF3.1
      DIMENSION TA(1),QCON(1)                                           DIMEN.6
C                                                                       DIMEN.7
      COMMON/VRCOM/A(36000)                                             VF3.2
      COMMON/CONCEN/ NSPS(10),PMAXNS(10),PMINNS(10),BKGS(10),FACS(10)   VF3.3
     1 ,IPEDIT(10),IPEL(10),IPES(10),PMIN(10)                           VF3.4
      COMMON /AMIX/ C(600)                                              COMM.5
      COMMON/FL/FO(20),FB(8),FM                                         COMM.6
      COMMON/FLS/FI(9)                                                  COMM.7
      COMMON/VRCON/ALX,ALY,ALZ,HO,BUFL,CEP,DT,DX(80),DXC,DY(80),DYC,    VF3.5
     1 DZ(80),DZC,EM0,EM6,ERF,GPX,GPY,GPZ,GX,GY,GZ,IBP1,IBP2,IBR,IBRED, VF3.6
     2 IBRIN,IBRST,IGOP(6),IJKMX,IJKNC,IJK2,IJP1K,IPL,IPR,ITER,I2JK2,   COMM.10
     * IKP2,IPARTF,IPLTF,ISFLG,RIBJBKB,LPR,DROU,                        COMM.11
     *IJKCON,ICON,JCON,                                                 COMM.12
     3 I2K2,JBP1,JBP2,JBR,JBRED,JBRIN,JBRST,JNC,JPA,JPF,J2NC,KBP1,KBP2, COMM.13
     4 KBR,KBRED,KBRIN,KBRST,KFP,KNC,KPB,KPT,KWA,KWB,KWF,KWL,KWR,KWT,   COMM.14
     5 K2NC,LABEL(8),LNPART,LNVRCM,LPARTC,NC1P,NCVIP(6),NCYC,NGOP,NOPI, COMM.15
     *NOCONC,                                                           COMM.16
     * OBLOC(1200),OBTYP(1200),NOB,NU,                                  VF3.7
     6 NOVP,NOVS,NPMX,NPRT,NTPE,NWPC,NWPP,PDX,PDY,PDZ,PT,PRFLM,RDT,     COMM.18
     7 RDX(80),RDY(80),RDZ(80),RRAN(20),SIGMA,TD,TD1,TD2,TFIN,TIMET,TIP,VF3.8
     8 TPL,TPLT,TPR,TPRT,TTO,TWIP,TWTD,UI,UP1,VD1,VDO,VI,VWTP(6),VPI,   COMM.20
     9 VIP,WI,WPI,WRAN(20),X(80),XPCEN,Y(80),YPCEN,Z(80),ZPCEN          VF3.9
      COMMON /MODSET/ SCFLM(200)                                        COMM.22
      COMMON /SAFLM/ XCONV,ZCONV,FX1,FX2,FX3,FX4,FY1,FY2,FY3,FY4,       COMM.23
     1 FXL,FYB,PXL,PYB,IFLB(3),FFX3(75),FFY3(75)                        COMM.24
     2 ,IICYC(3),XFC1(4),XFC2(4),YFC1(4),YFC2(4),PBTIM(2),XML,YML,ZML   COMM.25
     3 ,IFMID,IFTEST,IPLOPT,IPM(20),IPMM,IPPP,IPROJ,JPM(20),JPMM,JPPP,  COMM.26
     4 KPM(20),KPMM,KPPP,NEC,NMC,NPS,NPV,PEC(10),PMC(10),YCONV          COMM.27
     5 ,IFLAB,IFLIN,IFPNT,IFOPT,NCH,XFSP,XT,YFSP,YT                     COMM.28
      COMMON /ZLAST/ ZLAS                                               COMM.29
C                                                                       COMM.30
      EQUIVALENCE (A(1),U),(A(2),V),(A(3),W),(A(4),P),(A(5),CQ),        EQUIV.2
     1 (A(6),CQE), (A(7),VOL)                                           EQUIV.3
      EQUIVALENCE (C(1),TA,QCON)                                        EQUIV.7
C                                                                       EQUIV.8
    1 FORMAT(1H ,68H *** ERROR 006 - ATTEMPTED TO INSERT MORE PARTICLES VARP.1359
     1THAN ALLOWED ***)                                                 VARP.1360
    2 FORMAT(1H ,37H TOTAL NUMBER OF PARTICLES IN SYSTEM ,I8,4X,        VARP.1361
     17H TIME =,1PE12.5)                                                VARP.1362
    3 FORMAT(6(I4),3(F8.3),I4)                                          VARP.1363
    4 FORMAT(8(F8.3))                                                   VARP.1364
    5 FORMAT(1H ,4X,4HIPL=,I4/5X,4HIPR=,I4/5X,4HJPA=,I4/5X,4HJPF=,I4/   VARP.1365
     1 5X,4HKPT=,I4/5X,4HKPB=,I4/3X,6HXPCEN=,1PE12.5/3X,6HYPCEN=,E12.5/ VARP.1366
     2 3X,6HZPCEN=,E12.5/4X,5HNOPI=,I4)                                 VARP.1367
    6 FORMAT(1H ,4X,4HPDX=,1PE12.5/5X,4HPDY=,E12.5/5X,4HPDZ=,E12.5/     VARP.1368
     1 4X,5HTWIP=,E12.5/5X,4HUPI=,E12.5/5X,4HVPI=,E12.5/5X,4HWPI=,E12.5/VARP.1369
     2 3X,6HSIGMA=,E12.5)                                               VARP.1370
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VRPS
           7 FORMAT(1H ,2X,4H TIME = ,1PE12.5,8H CYCLE =,I6/3X,1HL,11X,2HXC,   VARP.1371
            1 15X,2HYC,15X,2HZC,15X,2HPM )                                      VARP.1372
           8 FORMAT(1H ,1X,I5,6(5X,1PE12.5))                                    VARP.1373
           9 FORMAT(1H ,28H TIME IN PARTICLE SECTION = ,1PE12.5)                VARP.1374
         100 NPF=0                                                              VARP.1375
      2      CALL SECOND(TP1)                                                   VARP.1376
      4      PRINT 13                                                           VARP.1377
          13 FORMAT( 1H ,*ENTERED PARTICLE SECTION*)                            VARP.1378
     10      IF( IPFLG.GT.0.OR. RRAN(20).GT.0.0) GO TO 210                      VARP.1379
           C ***** THIS SECTION , 200-299 , INITIALIZES PARTICLES AT T=0.0      VARP.1380
     20  200 READ(VDI,3) IPL,IPR,JPA,JPF,KPT,KPB,XPCEN,YPCEN,ZPCEN,NOPI          VARP.1381
     50      IF( IPL.EQ.0 ) GO TO 9500                                          VARP.1382
     51      READ(VDI,4) PDX,PDY,PDZ,TNIP,UPI,VPI,WPI,SIGMA                     VARP.1383
     75      WRITE(VDU,5) IPL,IPR,JPA,JPF,KPT,KPB,XPCEN,YPCEN,ZPCEN,NOPI        VARP.1384
    125      WRITE(VDU,6) PDX,PDY,PDZ,TNIP,UPI,VPI,WPI,SIGMA                    VARP.1385
           C    SINGLE SPECIES RIGHT NOW                                        VARP.1386
    151      NSPES=1                                                            VE3.44
    152      WAIR= 1.2                                                          VE3.45
    153      FACS(1)= 29./46.*1.E3/WAIR                                         VE3.46
    155      FACS(2)= 29./30.*1.E3/WAIR                                         VE3.47
    156      FACS(3)= 29./46.*1.E3/WAIR                                         VE3.48
           C..  THREE SPECIES PLUME DATA                                        VE3.49
    160      PMAXWS(1)= 2.0                                                     VE3.50
    161      PMAXWS(2)= 2.E-3                                                   VE3.51
    162      PMAXWS(3)= 5.E-4                                                   VE3.52
    164      PMIN(1)=1.0                                                        VE3.53
    165      PMIN(2)=.11E-2                                                     VE3.54
    167      PMIN(3)=-1.E-8                                                     VE3.55
    170      BKGS(1)=0.0                                                        VE3.56
    171      BKGS(2)=1.E-4                                                      VE3.57
    172      BKGS(3)=.5                                                         VE3.58
    174      TEM6=EM6+EM6                                                       VE3.59
    175      NOCONC=1                                                           VARP.1393
    176      IJKCON= IJK2 *NSPES                                                VARP.1394
    201      JCON= IBP2*KBP2                                                    VARP.1395
    203      ICON= KBP2                                                         VARP.1396
    204      NREAL= IJK2-JCON                                                   VARP.1397
    205      IPFLG=0                                                            VARP.1398
    206      WSUM=-0.1                                                          VARP.1399
    210      DO 209 L=1,20                                                      VARP.1400
    216      WSUM=WSUM+0.1                                                      VARP.1401
    217  209 RRAN(L)=WSUM                                                       VARP.1402
    220      RRAN(1)=0.00000                                                    VARP.1403
    221      RRAN(2)=0.11246                                                    VARP.1404
    222      RRAN(3)=0.22270                                                    VARP.1405
    224      RRAN(4)=0.32863                                                    VARP.1406
    225      RRAN(5)=0.42839                                                    VARP.1407
    227      RRAN(6)=0.52050                                                    VARP.1408
    230      RRAN(7)=0.60386                                                    VARP.1409
    232      RRAN(8)=0.67780                                                    VARP.1410
    233      RRAN(9)=0.74210                                                    VARP.1411
    235      RRAN(10)=0.79691                                                   VARP.1412
    236      RRAN(11)=0.84270                                                   VARP.1413
    240      RRAN(12)=0.88021                                                   VARP.1414
    241      RRAN(13)=0.91031                                                   VARP.1415
    243      RRAN(14)=0.93401                                                   VARP.1416
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VRPS
     244          RRAN(15)=0.95229                                                    VARP.1417
     246          RRAN(16)=0.96611                                                    VARP.1418
     247          RRAN(17)=0.97635                                                    VARP.1419
     251          RRAN(18)=0.98379                                                    VARP.1420
     252          RRAN(19)=0.98909                                                    VARP.1421
     254          RRAN(20)=0.99279                                                    VARP.1422
     256      210 IF( TIMEL.LT.TMIP ) RETURN                                          VARP.1423
     261          IF( IPFLG.GT.0 ) GO TO 500                                          VARP.1424
     264          TIP=TMIP                                                            VARP.1425
     264          IF( NOPI.GT.NPMX ) NOPI=NPMX                                        VARP.1426
     270          LC=-NWPP+1                                                          VE3.60
     272          NPS=NOPI                                                            VARP.1428
     273      230 DO 299 L=1,NPS                                                      VARP.1429
     275          LC=LC+NWPP                                                          VF3.61
          C ***** ASSIGN PARTICLES EITHER TO A POINT OR AREA                          VARP.1432
     276          IF(XPCEN.GT.0.0) GO TO 250                                          VARP.1433
     301          XPC(LC)= FLOAT(IPL) + FLOAT(IPR-IPL+1) * RANF(DUM)                  VARP.1434
     310          YPC(LC)= FLOAT(JPA) + FLOAT(JPF-JPA+1) * RANF(DUM)                  VARP.1435
     320          ZPC(LC)= FLOAT(KPB) + FLOAT(KPT-KPB+1) * RANF(DUM)                  VARP.1436
     330          GO TO 298                                                           VARP.1437
     331      250 CONTINUE                                                            VARP.1438
     332          XPC(LC)=XPCEN                                                       VARP.1439
     333          YPC(LC)=YPCEN                                                       VARP.1440
     335          ZPC(LC)=ZPCEN                                                       VARP.1441
     340      298 CONTINUE                                                            VARP.1442
          C *****  ASSIGN UNIT MASS TO PARTICLES                                      VARP.1443
     340          DO 297 N=1,NSPES                                                    VE3.62
     345          LLC=LC+N-1                                                          VE3.63
     347          PM(LLC)=PMIN(N)                                                     VF3.64
     350      297 CONTINUE                                                            VE3.65
     352      299 CONTINUE                                                            VARP.1445
     354          IPFLG=1                                                             VARP.1447
     355          GO TO 9500                                                          VARP.1448
          C ***** THIS SECTION , 500 , PREASSIGNS LOGIC FLOW TYPES OF PART EQUATIOVARP.1449
     356      500 GO TO( 510,520                                   ),NTPE             VARP.1450
          C ***** THIS SECTION , 510 , PREASSIGNS FLOW FOR MARKER PARTICLE EQUATIOVARP.1451
     364      510 ASSIGN 2000 TO KPE                                                  VARP.1452
     365          ASSIGN 8000 TO KMPE                                                 VARP.1453
          C *****  SECOND ORDER PARTICLE MOVEMENT ANYONES, SET KMPO TO 2400           VARP.1454
     366          ASSIGN 2400 TO KMPO                                                 VF3.66
     367          GO TO 600                                                           VARP.1456
          C ***** THIS SECTION , 520 , PREASSIGNS FLOW FOR TURBULENT DISPERSION EQVARP.1457
     370      520 ASSIGN 2000 TO KPE                                                  VARP.1458
     371          ASSIGN 3000 TO KMPE                                                 VARP.1459
     372          ASSIGN 8000 TO KIDE                                                 VARP.1460
     373          ASSIGN 2400 TO KMPO                                                 VF3.67
          C ***** THIS SECTION,600, ZEROS THE CONCENTRATION ARRAY, CONC.              VARP.1462
     374      600 IF( NOCONC.LT.1) GO TO 1000                                         VARP.1463
     377          DO 610 I=1,IJKCON                                                   VARP.1464
     403      610 CON(I)= 0.0                                                         VARP.1465
     405          GO TO 1000                                                          VARP.1466
          C ***** BEGIN MAJOR LOOP FOR CALCULATION OF PARTICLE TRANSPORT MODEL        VARP.1467
     405     1000 CONTINUE                                                            VE3.68
     405          NPF=0                                                               VARP.1472
     406          IF(NPS.LE.0) GO TO 9000                                             VF3.69
     410          NPL=0                                                               VF3.70
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 411          LF=I-NMPP+NPL                                                  VARP,1473
 413          LC=I-NMPP+NPL                                                  VARP,1474
      C ***** THIS SECTION , 1050 , PREASSIGNS DRG(),PM() TO CONSTANTS       VARP,1475
 414   1050   DRGC=0.0                                                       VARP,1476
 415          PMK= 0.0                                                       VARP,1477
 416          DDPM=0.0                                                       VARP,1478
 416          DDT= DT                                                        VF3.71
 420   1100   DO 8999 L=1,NPS                                                VARP,1479
 422          DT= DDT                                                        VF3.72
 423          IF( L.LE. NPS-NOPI) GO TO 1120                                 VF3.73
 427          DT= DDT* (NPS-L) /NOPI                                         VF3.74
 433   1120   LC=LC+NMPP                                                     VARP,1480
 435   1200   GO TO KPE,( 2000,3000                        )                 VARP,1481
      C ***** THIS SECTION , 2000-2600 , CALCULATES SIMPLE MARKER PARTICLES  VARP,1482
 440   2000   CONTINUE                                                       VARP,1483
 444          XC=XPC(LC)                                                     VARP,1484
 445          IX=IFIX(XC+EM6)                                                VARP,1485
 446          YC=YPC(LC)                                                     VARP,1486
 450          IY=IFIX(YC+EM6)                                                VARP,1487
 451          ZC=ZPC(LC)                                                     VARP,1488
 452          IZ=IFIX(ZC+EM6)                                                VARP,1489
 454          XW=XC-FLOAT(IX)                                                VARP,1490
 456          YL=YC-FLOAT(IY)                                                VARP,1491
 460          ZH=ZC-FLOAT(IZ)                                                VARP,1492
 463          IX1=IX+SIGN(1.,XW-.5)                                          VARP,1493
 470          XW1=ABS(XW-.5)                                                 VARP,1494
 472          IY1=IY+SIGN(1.,YL-.5)                                          VARP,1495
 477          YL1=ABS(YL-.5)                                                 VARP,1496
 501          IZ1=IZ+SIGN(1.,ZH-.5)                                          VARP,1497
 507          ZH1=ABS(ZH-.5)                                                 VARP,1498
 511          I=(IX-1)*K2NC                                                  VARP,1499
 514          J=(IY-1)*I2K2                                                  VARP,1500
 516          K=(IZ-1)*NWPC+1                                                VARP,1501
 522          I1=(IX1-1)*K2NC                                                VARP,1502
 524          J1=(IY1-1)*I2K2                                                VARP,1503
 530          K1=(IZ1-1)*NWPC+1                                              VARP,1504
 533          IM=I-K2NC                                                      VARP,1505
 535          JM=J-I2K2                                                      VARP,1506
 537          KM=K-NWPC                                                      VARP,1507
 541          IJK=I+J+K                                                      VARP,1508
 543          XW1M=1.-XW1                                                    VARP,1509
 545          YL1M=1.-YL1                                                    VARP,1510
 546          ZH1M=1.-ZH1                                                    VARP,1511
      C ***** THIS SECTION , 2100 , CALCULATES U-FLUID VELOCITY              VARP,1512
 550   2100   UR=(YL1M*(ZH1*U(I+J+K1)+ZH1M*U(IJK))                           VARP,1513
     *           +YL1*(ZH1*U(I+J1+K1)+ZH1M*U(I+J1+K)))                       VARP,1514
 567          UL=(YL1M*(ZH1*U(IM+J+K1)+ZH1M*U(IM+J+K))                       VARP,1515
     *           +YL1*(ZH1*U(IM+J1+K1)+ZH1M*U(IM+J1+K)))                     VARP,1516
      C ***** THIS SECTION , 2200 , CALCULATES W-FLUID VELOCITY              VARP,1517
 607   2200   WT=(XW1M*(YL1*W(I+J1+K)+YL1M*W(IJK))                           VARP,1518
     *           +XW1*(YL1*W(I1+J1+K)+YL1M*W(I1+J+K)))                       VARP,1519
 626          WB= (XW1M* (YL1*W(I+J1+KM)+ YL1M*W(I+J+KM))                    VARP,1520
     *           +XW1*(YL1*W(I1+J1+KM)+YL1M*W(I1+J+KM)))                     VARP,1521
      C ***** THIS SECTION , 2300 , CALCULATES V-FLUID VELOCITY.             VARP,1522
 650   2300   VF=(ZH1M*(XW1*V(I1+J+K)+XW1M*V(IJK))                           VARP,1523
     *           +ZH1*(XW1*V(I1+J+K1)+XW1M*V(I+J+K1)))                       VARP,1524
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VHPS
       667             VA=(ZH1M*(XM1*V(I1+JM+K)+XM1M*V(I+JM+K))                     VARP.1525
                    *   +ZH1*(XM1*V(I1+JM+K1)+XM1M*V(I+JM+K1)))                     VARP.1526
                C ***** THIS SECTION COMPUTES FIRST ORDER PARTICLE ADVECTION         VARP.1527
       707             UFL=XM*UR + (1.0-XM)*UL                                      VARP.1528
       719             WFL=ZM*WT + (1.0-ZH)*WB                                      VARP.1529
       720             VFL=YL*VF + (1.0-YL)*VA                                      VARP.1530
       725             GO TO KMPD, (2400,2600       )                               VARP.1531
                C **** THIS SECTION, 2600, COMPUTES SECOND ORDER PARTICLE ADVECTION  VARP.1532
       730  2400  UFL=UFL*(1.0+0.5*DT*RDX(IX)*(UR-UL))                              VARP.1533
       736             WFL=WFL*(1.0+0.5*DT*RDZ(IZ)*(WT-WB))                         VARP.1534
       745             VFL=VFL*(1.0+0.5*DT*RDY(IY)*(VF-VA))                         VARP.1535
                C ***** THIS SECTION , 2600 , COLLECTS TRANSPORT TERMS              VARP.1536
       753  2600  UPAR=UFL                                                          VARP.1537
       754             WPAR=WFL                                                     VARP.1538
       756             VPAR=VFL                                                     VARP.1539
       760             GO TO KMPE,( 3000,8000                        )              VARP.1540
                C ***** THIS SECTION , 3000-3600 , CALCULATES TURBULENT DISPERSION  VARP.1541
       763  3000  CONTINUE                                                          VARP.1542
       763             DO 3099 M=1,3                                                VARP.1543
       765             IF(M-2) 3001,3002,3003                                       VE3.75
       767  3001  SIGMA=10.0                                                        VE3.76
       771             GO TO 3010                                                   VE3.77
       771  3002  SIGMA=10.0                                                        VE3.78
       773             GO TO 3010                                                   VE3.79
       773  3003  SIGMA=5.0                                                         VE3.80
       775  3010  ZETA=RANF(DUM)                                                    VARP.1544
      1000             ZETSIN=1.-2.*ZETA                                            VARP.1545
      1003             ZETA=ABS(ZETSIN)                                             VARP.1546
      1004             ZETSIN=SIGN(1.,ZETSIN)                                       VARP.1547
      1006             LT=10                                                        VARP.1548
      1007             LTM=5                                                        VARP.1549
      1010             LTP=15                                                       VARP.1550
      1011             LTMX=20                                                      VARP.1551
      1012             IF( ZETA.GT.RRAN(LT) ) GO TO 3020                            VARP.1552
      1016             IF( ZETA.GT.RRAN(LTM) ) GO TO 3015                           VARP.1553
      1021             L1=LTM                                                       VARP.1554
      1021  3012  IF( ZETA.GE.RRAN(L1) ) GO TO 3030                                 VARP.1555
      1024             L1=L1-1                                                      VARP.1556
      1025             GO TO 3012                                                   VARP.1557
      1026  3015  L1=LT                                                             VARP.1558
      1030  3017  IF( ZETA.GE.RRAN(L1) ) GO TO 3030                                 VARP.1559
      1033             L1=L1-1                                                      VARP.1560
      1034             GO TO 3017                                                   VARP.1561
      1035  3020  IF( ZETA.GT.RRAN(LTP) ) GO TO 3025                                VARP.1562
      1041             L1=LTP                                                       VARP.1563
      1041  3022  IF( ZETA.GE.RRAN(L1) ) GO TO 3030                                 VARP.1564
      1044             L1=L1-1                                                      VARP.1565
      1045             GO TO 3022                                                   VARP.1566
      1046  3025  L1=LTMX                                                           VARP.1567
      1050  3027  IF( ZETA.GE.RRAN(L1) ) GO TO 3030                                 VARP.1568
      1053             L1=L1-1                                                      VARP.1569
      1054             GO TO 3027                                                   VARP.1570
      1055  3030  IF( L1.EQ.LTMX .AND. ZETA.GT.RRAN(L1) ) GO TO 3010                VARP.1571
      1065             W1=WRAN(L1) + (WRAN(L1+1)-WRAN(L1))*(ZETA-RRAN(L1))          VARP.1572
                    1 /(RRAN(L1+1)-RRAN(L1))                                        VARP.1573
      1074             W2=SQRT(4.*SIGMA*RDT)*W1*ZETSIN                              VARP.1574
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VRPS
    1103          GO TO(3040,3050,3060),M                                       VARP.1575
    1112   3040   URAND=W2                                                      VARP.1576
    1113          GO TO 3099                                                    VARP.1577
    1114   3050   VRAND=W2                                                      VARP.1578
    1116          GO TO 3099                                                    VARP.1579
    1116   3060   WRAND=W2                                                      VARP.1580
    1120   3099   CONTINUE                                                      VARP.1581
    1122          UPAR=UFL+URAND                                                VARP.1582
    1124          VPAR=VFL+VRAND                                                VARP.1583
    1126          WPAR=WFL+WRAND                                                VARP.1586
    1130          GO TO KIDE,( 8000                               )             VARP.1587
           C ***** THIS SECTION , 8000 , CALCULATES THE TRANSPORT CONTRIBUTION  VARP.1588
           C      REFLECTIVE BOUNDARIES FOR OBSTACLES                           VARP.1589
    1133   8000   XWN=XW+UPAR*DT*RDX(IX)                                        VARP.1590
    1137          XC=FLOAT(IX)+XWN                                              VARP.1591
    1141          IF(XWN.GT.0.0) GO TO 8010                                     VARP.1592
    1143          IF(U(IJK-K2NC).EQ.0) GO TO 8005                               VARP.1593
    1145          XC=FLOAT(IX)+XWN*DX(IX)*RDX(IX-1)                             VARP.1594
    1151          GO TO 8020                                                    VARP.1595
    1151   8005   XC=FLOAT(IX)-XWN                                              VARP.1596
    1154          GO TO 8020                                                    VARP.1597
    1154   8010   IF(XWN.LT.1.0) GO TO 8020                                     VARP.1598
    1157          IF(U(IJK).EQ.0) GO TO 8015                                    VARP.1599
    1160          XC=FLOAT(IX)+1.0+(XWN-1.)*DX(IX)*RDX(IX+1)                    VARP.1600
    1165          GO TO 8020                                                    VARP.1601
    1165   8015   XC=FLOAT(IX)+2.0-XWN                                          VARP.1602
    1171   8020   CONTINUE                                                      VARP.1603
    1171          YLN=YL + VPAR*DT*RDY(IY)                                      VARP.1604
    1175          YC=FLOAT(IY) + YLN                                            VARP.1605
    1177          IF(YLN.GT.0) GO TO 8030                                       VARP.1606
    1201          IF(V(IJK -I2K2).EQ.0) GO TO 8025                              VARP.1607
    1203          YC= FLOAT(IY)+YLN * DY(IY)*RDY(IY-1)                          VARP.1608
    1207          GO TO 8040                                                    VARP.1609
    1207    8025 YC= FLOAT(IY)-YLN                                              VARP.1610
    1212          GO TO 8040                                                    VARP.1611
    1212    8030 IF(YLN.LT.1) GO TO 8040                                        VARP.1612
    1215          IF(V(IJK).EQ.0) GO TO 8035                                    VARP.1613
    1217          YC= FLOAT(IY)+1.0+ (YLN-1.) *DY(IY)*RDY(IY+1)                 VARP.1614
    1224          GO TO 8040                                                    VARP.1615
    1225    8035 YC= FLOAT(IY)+2.0-YLN                                          VARP.1616
    1231    8040 CONTINUE                                                       VARP.1617
    1231          ZHN=ZH + WPAR*DT*RDZ(IZ)                                      VARP.1618
    1235          ZC=FLOAT(IZ) + ZHN                                            VARP.1619
    1237          IF( ZHN.GT.0) GO TO 8050                                      VARP.1620
    1241          IF( W(IJK-NXPC). EQ. 0) GO TO 8045                            VARP.1621
    1243          ZC= FLOAT(IZ)+ZHN * DZ(IZ)*RDZ(IZ-1)                          VARP.1622
    1247          GO TO 8060                                                    VARP.1623
    1247    8045 ZC= FLOAT(IZ)- ZHN                                             VARP.1624
    1252          GO TO 8060                                                    VARP.1625
    1252    8050 IF( ZHN.LT.1) GO TO 8060                                       VARP.1626
    1255          IF( W(IJK).EQ.0) GO TO 8055                                   VARP.1627
    1257          ZC= FLOAT(IZ)+1.0 + (ZHN-1.0) *DZ(IZ)*RDZ(IZ+1)               VARP.1628
    1264          GO TO 8060                                                    VARP.1629
    1265    8055 ZC= FLOAT(IZ)+2.0-ZHN                                          VARP.1630
    1271    8060 CONTINUE                                                       VARP.1631
    1271          IX= IFIX(XC)                                                  VE3.61
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1272        IY= IFIX(YC)                                                VE3.82
1274        IZ= IFIX(ZC)                                                VE3.83
1275        IF(IX.LT.2.OR.IX.GT.IHP1) GO TO 8990                        VARP.1632
1305        IF(IY.LT.2.OR.IY.GT.JBP1) GO TO 8990                        VARP.1633
1314        IF(IZ.GT.KBP1) GO TO 8990                                   VARP.1634
1317        IF(IZ.LT.2) ZPC(LC)= 2.+ (2.-ZC)                            VARP.1635
1324        NPF= NPF+1                                                  VARP.1639
1326        LF= LF+NNPP                                                 VARP.1640
1327        XPC(LF)=XC                                                  VARP.1641
1331        YPC(LF)=YC                                                  VARP.1642
1333        ZPC(LF)=ZC                                                  VARP.1643
1336        DO 8061 N=1,NSPES                                           VE3.84
1342        LLF=LF+N-1                                                  VE3.85
1344        LLC=LC+N-1                                                  VE3.86
1345        PM(LLF)=PM(LLC)                                             VE3.87
1350  8061  CONTINUE                                                    VE3.88
1351        IF(NOCONC.LT.1) GO TO 8990                                  VARP.1645
      C ***** THIS SECTION COMPUTES MASSES AT GRID NODES.               VARP.1646
1353        I=IX                                                        VARP.1648
1354        J=IY                                                        VARP.1649
1355        K=IZ                                                        VARP.1650
1357        DO 8989 N=1,NSPES                                           VE3.89
1375        IJK=((I-1)*ICON+(J-1)*JCON+K)+(IJK2 )*(N-1)                 VARP.1665
1400        LLC=LC+N-1                                                  VE3.90
1401        PMK=PM(LLC)                                                 VE3.91
1404        F1= 1.0                                                     VE3.92
1405        CON(IJK)=F1*PMK+CON(IJK)                                    VARP.1675
1410  8989  CONTINUE                                                    VE3.93
1413  8990  CONTINUE                                                    VARP.1681
1413  8999  CONTINUE                                                    VARP.1682
1416        DI= DDI                                                     VE3.94
1417        NPS=NPF                                                     VE3.95
1420  9000  CONTINUE                                                    VARP.1684
      C ***** THIS SECTION, 4000, DIVIDES NODE MASSES BY VOLUMES TO COMPUTE   VARP.1685
      C        CONCENTRATIONS.                                          VARP.1686
1420        IF(NOCONC.LT.1) GO TO 4999                                  VARP.1687
1423        NCON=-IJK2                                                  VARP.1688
1424        DO 4000 N=1,NSPES                                           VE3.96
1427        BKG= BKGS(N)                                                VE3.97
1430        FAC= FACS(N)                                                VE3.98
1431        NCON=NCON+IJK2                                              VARP.1690
1433        DO 4000 L=1,MREAL                                           VARP.1691
1435        LCON=L+NCON                                                 VARP.1692
1436        LVOL=(L-1)*NNPC+1                                           VARP.1693
1441        IF( VOL(LVOL).EQ.0) GO TO 4000                              VARP.1694
1445        VOL(LVOL)= 1.0                                              VE3.99
1447        CON(LCON)= (CON(LCON)/VOL(LVOL)) * FAC+BKG                  VE3.100
1453   4000 CONTINUE                                                    VARP.1696
1460        IF(MOD(NCYC+1,100).NE.0) GO TO 8100                         VE3.101
1465        DO 8099 N=1,NSPES                                           VE3.102
1467        DO 8099 J=1,JHP1                                            VARP.1697
1470        PRINT 8801,J,N                                              VE3.103
1477        JMJC= (J-1)*JCON                                            VARP.1699
       8801 FORMAT( 1H0 9HFACE NO. ,I2,10X,14HCONCENTRATIONS ,10X,      VE3.104
           1 12HSPECIES NO. ,I2)                                        VE3.105
1503        DO 8099 I=1,IBP1                                            VE3.106
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NP3
    1521        IJC= (I-1)*ICON+J*JC+(N-1)*IJK2 + 1                          VF3.107
    1514        IJL= IJC+NNP                                                  VF3.108
    1516        PRINT 8852 ,I,(CON(IJK),IJK=IJC,IJL)                          VF3.109
           8852 FORMAT(1H ,I2,1H-I,11(1X,1PE11.5))                            VF3.110
    1531   [illegible] CONTINUE                                               VARP.1718
    1541   [illegible] CONTINUE                                               VF3.111
         C ***** THIS SECTION, 4100, CALLS OUTPUT FOR PARTICLES AND           VARP.1719
         C        CONCENTRATIONS.                                             VARP.1720
         C ***** THIS SECTION, 4200, CALLS KEM AND ADDS NEW PARTICLES.        VARP.1721
    1541        DO 4299 I=2,IMPP                                              VF3.112
    1543        DO 4299 J=2,JMPP                                              VF3.113
    1544        DO 4299 K=2,KMPP                                              VF3.114
    1545        L=(K-2) + (J-2)*JCON + (I-2)*ICON                             VF3.115
    [illegible] [illegible]                                                   VF3.116
                [illegible]                                                   VF3.117
    1560        DO 4003 NN=1,NSPES                                            VF3.118
    1566        LFIELD= L+LFIELD+IJK2                                         VF3.119
    1570        SPEC(NN)= CON(LFIELD)                                         VF3.120
    1572        TSP(NN)= SPEC(NN)-BKGS(NN)                                    VF3.121
    1573        TV= TV+ABS(TSP(NN) /BKGS(NN))                                 VF3.122
    1576   4003 CONTINUE                                                      VF3.123
    1600        IF( TV.GT.1.E-5) GO TO 4005                                   VF3.124
    1603        LFIFLD= -IJK2                                                 VF3.125
    1604        DO 4004 NN=1,NSPES                                            VF3.126
    1611        LFIFLD= L+LFIELD+IJK2                                         VF3.127
    1613        CON(LFIELD)= 1.0                                              VF3.128
    1614   4004 CONTINUE                                                      VF3.129
    1616        GO TO 4299                                                    VF3.130
    1616   4005 CONTINUE                                                      VF3.131
    1616        CALL KEM(SPEC,DT,NSPES)                                       VF3.132
    1621        LFIELD= -IJK2                                                 VF3.133
         C      UPDATE CONCENTRATIONS                                         VF3.134
    1623        DO 4006 NN=1,NSPES                                            VF3.135
    1631        LFIFLD= LFIELD+L+IJK2                                         VF3.136
    1633        TV= SPEC(NN)- BKGS(NN)                                        VF3.137
    1634        CON(LFIFLD)= TV/TSP(NN)                                       VF3.138
    1636   4006 CONTINUE                                                      VF3.139
    1641   4299 CONTINUE                                                      VARP.1811
         C ***** THIS SECTION, 4300, REWEIGHTS PARTICLES AND SETS PARTICLE EDIT  VARP.1812
         C        FLAG                                                        VARP.1813
    1651        NPL=NPS                                                       VF3.140
    1652        LC=1-NAPP                                                     VF3.141
    1654        IMAX=0                                                        VARP.1818
    1654        IMIN=0                                                        VARP.1819
    1655        IF(NPS.LE.0) GO TO 4310                                       VARP.1824
    1656        DO 4300 L=1,NPS                                               VARP.1825
    1660        LC=LC+NAPP                                                    VARP.1826
    1661        XC= XPC(LC)                                                   VARP.1827
    1663        YC= YPC(LC)                                                   VARP.1828
    1664        ZC= ZPC(LC)                                                   VARP.1829
    1666        I= IFIX(XC)                                                   VARP.1830
    1667        J= IFIX(YC)                                                   VARP.1831
    1671        K= IFIX(ZC)                                                   VARP.1832
    1673        DO 4301 N=1,NSPES                                             VF3.142
    1710        IJK=((I-1)*ICON+(J-1)*JCON+K)+(IJK2 )*(N-1)                   VARP.1847
    1713        PNK= CON(IJK)                                                 VF3.143
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VRPS
  1715         LLC=LC+N-1                                                     VE3.144
  1717         PM(LLC)=PM(LLC)*PNK                                            VE3.145
  1721  4301   CONTINUE                                                       VE3.146
  1723   4300  CONTINUE                                                       VARP.1863
  1725   4310  CONTINUE                                                       VARP.1865
  1725  4999   CONTINUE                                                       VARP.1924
  1725         IF( TIMET.LT.TNIP ) GO TO 9500                                 VARP.1926
  1730         IF( TIP.EQ.0.0 ) GO TO 9500                                    VARP.1927
       C ***** THIS SECTION , 9100-9199 , ADDS PARTICLES TO THE SYSTEM        VARP.1928
  1731  9100   TNIP=TNIP+TIP                                                  VARP.1929
  1733         LC=1 + NWPP * (NPS-1)                                          VE3.147
  1736         L1=NPS+1                                                       VARP.1930
  1737         NPS=NPS+NUPI                                                   VARP.1931
  1741         IF( NPS.GT.NPMX ) GO TO 9200                                   VARP.1932
  1744  9110   DO 9199 L=L1,NPS                                               VARP.1933
  1746   9120  LC= LC+NWPP                                                    VE3.148
  1750         IF(XPCEN.GT.0.0) GO TO 9130                                    VARP.1936
  1752         XPC(LC)= FLOAT(IPL) + FLOAT(IPR-IPL+1) * RANF(DUM)             VARP.1937
  1761         YPC(LC)= FLOAT(JPA) + FLOAT(JPF-JPA+1) * RANF(DUM)             VARP.1938
  1771         ZPC(LC)= FLOAT(KPB) + FLOAT(KPT-KPB+1) * RANF(DUM)             VARP.1939
  2001         GO TO 9198                                                     VARP.1940
  2002  9130   CONTINUE                                                       VARP.1941
  2003         XPC(LC)=XPCEN                                                  VARP.1942
  2004         YPC(LC)=YPCEN                                                  VARP.1943
  2006         ZPC(LC)=ZPCEN                                                  VARP.1944
  2011  9198   CONTINUE                                                       VARP.1945
  2011         DO 9199 N=1,NSPES                                              VE3.149
  2016         LLC=LC+N-1                                                     VE3.150
  2020         PM(LLC)=PMIN(N)                                                VE3.151
  2021  9199   CONTINUE                                                       VARP.1948
  2025  9197   CONTINUE                                                       VE3.152
  2025         GO TO 9500                                                     VARP.1950
       C ***** *** ERROR 006 - ATTEMPTED TO INSERT MORE PARTICLES THAN ALLOWED VARP.1951
  2026  9200   WRITE(VDO,1)                                                   VARP.1952
  2032         ERF=1                                                          VARP.1953
  2033  9500   CONTINUE                                                       VE3.153
  2033         WRITE(VDO,2) NPS, TIMET                                        VARP.1955
  2043         IF( LPR.EQ.1 ) GO TO 9600                                      VARP.1956
  2045         VDO=6                                                          VARP.1957
  2046         IF( LPR.EQ.2 ) VDO=9                                           VARP.1958
  2051         LC= 1 - NWPP                                                   VE3.154
  2053         WRITE(VDO,7) TIMET,NCYC                                        VARP.1960
  2063         LL=10                                                          VE3.155
  2064         IF(MOD(NCYC+1,20).NE.0) GO TO 9600                             VE3.156
  2071         DO 9599 L=1,LL                                                 VE3.157
  2073         LC=LC + NWPP                                                   VE3.158
  2074         XC=XPC(LC)                                                     VARP.1963
  2076         IX=IFIX(XC+EM6)                                                VARP.1964
  2100         XW=XC - FLOAT(IX)                                              VARP.1965
  2102         YC=YPC(LC)                                                     VARP.1966
  2104         IY=IFIX(YC+EM6)                                                VARP.1967
  2106         YL=YC - FLOAT(IY)                                              VARP.1968
  2111         ZC=ZPC(LC)                                                     VARP.1969
  2112         IZ=IFIX(ZC+EM6)                                                VARP.1970
  2114         ZW=ZC - FLOAT(IZ)                                              VARP.1971
  2117         XP=X(IX-1) + XW*DX(IX)                                         VARP.1972
```

```
RPS
    2122          YP=Y(IY-1) + YL*DY(IY)                                           VARP.1973
    2126          ZP=Z(IZ-1) + ZH*DZ(IZ)                                           VARP.1974
    2131          PMK1=PM(LC)                                                      VE3.159
    2133          PMK2=PM(LC+1)                                                    VE3.160
    2135          PMK3=PM(LC+2)                                                    VE3.161
    2137          WRITE(VDO,8) L,XC,YC,ZC,PMK1,PMK2,PMK3                           VE3.162
    2160          IF( VPS.EQ.0) GO TO 9599                                         VARP.1977
    2161          VPL=0                                                            VARP.1978
    2162   9599   CONTINUE                                                         VARP.1979
    2165   9600   VDO=6                                                            VARP.1980
    2166          CALL SECUND(TP2)                                                 VARP.1981
    2170          TP3=TP2-TP1                                                      VARP.1982
    2172          WRITE(6,9) TP3                                                   VARP.1983
    2200  99999   RETURN                                                           VARP.1984
    2201          END                                                              VARP.1985


  SUBPROGRAM LENGTH

  02713

  FUNCTION ASSIGNMENTS

  STATEMENT ASSIGNMENTS
  1       - 002205   2       - 002216   3       - 002227   4       - 002232   5       - 002235   6       - 002257
  7       - 002277   8       - 002312   9       - 002316   13      - 002325   100     - 000002   200     - 000021
  210     - 000257   230     - 000274   250     - 000332   298     - 000341   500     - 000357   510     - 000365
  520     - 000371   600     - 000375   1000    - 000406   1050    - 000415   1100    - 000421   1120    - 000434
  1200    - 000436   2000    - 000441   2100    - 000551   2200    - 000610   2300    - 000651   2400    - 000731
  2600    - 000754   3000    - 000760   3001    - 000770   3002    - 000772   3003    - 000774   3010    - 000776
  3012    - 001022   3015    - 001027   3017    - 001031   3020    - 001036   3022    - 001042   3025    - 001047
  3027    - 001051   3030    - 001056   3040    - 001113   3050    - 001115   3060    - 001117   3099    - 001121
  4000    - 001454   4005    - 001617   4299    - 001642   4310    - 001726   4999    - 001726   8000    - 001134
  8005    - 001152   8010    - 001155   8015    - 001166   8020    - 001172   8025    - 001210   8030    - 001213
  8035    - 001226   8040    - 001232   8045    - 001250   8050    - 001253   8055    - 001266   8060    - 001272
  8100    - 001542   8801    - 002406   8802    - 002420   8990    - 001414   8999    - 001414   9000    - 001421
  9100    - 001732   9110    - 001745   9120    - 001747   9130    - 002005   9197    - 002026   9198    - 002012
  9200    - 002027   9500    - 002034   9599    - 002163   9600    - 002166   99999   - 002201

  BLOCK NAMES AND LENGTHS
    *LCM*- 0127710
  VRCOM  - 106240/01  CONCEN - 000132/02  AMIX   - 001130/03  FL     - 000035/04  FLS    - 000011/05  VRCON  - 006352/06
  MODSET - 000310/07  SAFLM  - 000447/08  ZLAST  - 000001/11

  VARIABLE ASSIGNMENTS
  A      - 000000/01  ABC    - 0000004/LC BKG    - 002666     BKGS   - 000036/02  BUFL   - 000004/06  C      - 000000/03
  CON    - 0072460/LC CPRT   - 002514     CU     - 000004/01  CUF    - 000005/01  DDT    - 002573     DUPM   - 002572
  DRGC   - 002570     DT     - 000006/06  DUM    - 002556     DX     - 000007/06  DY     - 000130/06  DZ     - 000251/06
  EM6    - 000373/06  FMF    - 000374/06  F      - 002511     FAC    - 002667     FACS   - 000050/02  FH     - 000024/04
  FFX3   - 000021/08  FFY3   - 000134/08  FI     - 000000/05  FM     - 000034/04  FO     - 000000/04  F1     - 002664
  I      - 002565     IBP1   - 000403/06  IBP2   - 000404/06  ICON   - 000437/06  IFLB   - 000014/08  IGOP   - 000411/06
  IJC    - 002673     IJK    - 002623     IJKCON - 000436/06  IJK2   - 000421/06  IJL    - 002674     IH     - 002620
  IMAX   - 002700     IMIN   - 002701     IPEDIT - 000062/02  IPEL   - 000074/02  IPFS   - 000106/02  IPFLG  - 002546
  IPL    - 000023/06  IPM    - 000302/08  IPR    - 000424/06  ITCYC  - 000247/08  IX     - 002575     IX1    - 002605
  IY     - 002577     IY1    - 002607     IZ     - 002601     IZ1    - 002611     I1     - 002615     I2K2   - 000441/06
```

```
KEM
              SUBROUTINE KEM(SPEC,DT,NSPES)                                    VE3.161
        C                                                                      VE3.162
        C     X= NO2,    Y= NO,    TOX= NO2+O3,    TNO= NO2+NO,    Z=O3        VE3.163
        C                                                                      VE3.164
              DIMENSION SPEC(10),TSP(10)                                       VE3.165
              DATA C1,C3/0.4,10.0/                                             VE3.166
              X= SPEC(1)                                                       VE3.167
     5        Y= SPEC(2)                                                       VE3.168
     7        Z= SPEC(3)                                                       VE3.169
    10        DDT=(DT/60.)*100.                                                VE3.170
    13        IF( Z.LT.0.0) GO TO 600                                          VE3.171
    15           IF( X.LE.0.) X= 1.E-6                                         VE3.172
    17        IF( Y.LE.0.) Y= 1.E-6                                            VE3.173
    22        IF( Z.LE.0.) Z= 1.E-6                                            VE3.174
    26        TOX= X+Z                                                         VE3.175
    27        TNO= X+Y                                                         VE3.176
    30        A= C3                                                            VE3.177
    31        B= -C1-C3*  (TOX+TNO)                                            VE3.178
    34        C= C3*TOX*TNO                                                    VE3.179
    35        B2= B*B-4.*A*C                                                   VE3.180
    41        IF( B2) 900,400,100                                              VE3.181
    42    100 R= SQRT(B2)                                                      VE3.182
    44        ALPHA= (2.*A*X +B)/R                                             VE3.183
    51        IF( ABS(ALPHA).LT.1.) CON= ALOG(( 1.+ALPHA)/ (1.-ALPHA))/R       VE3.184
    64        IF( ABS(ALPHA).GT.1.) CON= ALOG(( ALPHA+1.)/(ALPHA-1.)) /R       VE3.185
   100        TAU= 2./R+CON                                                    VE3.186
   103        IF(ABS(TAU).GT.DDT*0.1) GO TO 200                                VE3.187
   112        X1= (-B-R)/(2.*A)                                                VE3.188
   115        GO TO 500                                                        VE3.189
   116    200 CONTINUE                                                         VE3.190
   116        XX= -(DDT-CON)*R*0.5                                             VE3.191
   122        EXP1= EXP(XX)                                                    VE3.192
   124        EXP2= EXP(-XX)                                                   VE3.193
   130        IF( ABS(ALPHA).GT. 1.0)  GO TO 250                               VE3.194
   137        F= (EXP1-EXP2)/ (EXP1+EXP2)                                      VE3.195
   142        GO TO 300                                                        VE3.196
   143    250 F= (EXP1+EXP2)/(EXP1-EXP2)                                       VE3.197
   147    300 X1= (-B+R*F)/( 2.*A)                                             VE3.198
   154        GO TO 500                                                        VE3.199
   154    400 CON= 2./(2.*A*X+B)                                               VE3.200
   160        X1= ((2./(DDT-CON)) -B)/(2.*A)                                   VE3.201
   164    500 Y1= TNO-X1                                                       VE3.202
   166        Z1= TOX-X1                                                       VE3.203
   167        X= X1                                                            VE3.204
   170        Y= Y1                                                            VE3.205
   172        Z= Z1                                                            VE3.206
   173        IF( X.LE.0.) X= 1.E-6                                            VE3.207
   176        IF( Y.LE.0.) Y= 1.E-6                                            VE3.208
   201        IF( Z.LE.0.) Z= 1.E-6                                            VE3.209
   204        GO TO 1000                                                       VE3.210
   205    900 STOP                                                             VE3.211
   207    600 X= X+Z-1.E-6                                                     VE3.212
   212        Z=1.E-6                                                          VE3.213
   212        Y = Y                                                            VE3.214
   214   1000 RETURN                                                           VE3.215
   215        END                                                              VE3.216
```

```
      SUBROUTINE VRIO                                                   VARP.1995
      LARGE XPC(1),YPC(1),ZPC(1)                                        VE3.217
      INTEGER F,ENF,VDI,VDO,BUFL,PYML,PXML,CPRT,VNTP,VTP,PF,TD,TD1,TD2, INREAL.2
     1 PRELM,COE,SHIFT,OBLOC,OBTYP,FI,FO,FB,FM,OBTYPL                   INREAL.3
      REAL NU                                                           INREAL.4
C                                                                       INREAL.5
      DIMENSION U(1),V(1),W(1),P(1),CQ(1),CQF(1)                        DIMEN.2
     1 ,VOL(1)                                                          DIMEN.5
      DIMENSION SPEC(10),TSP(10)                                        VE3.1
      DIMENSION TA(1),WCON(1)                                           DIMEN.6
C                                                                       DIMEN.7
      COMMON/VRCOM/A(36000)                                             VE3.2
      COMMON/CONCEN/ NSPS(10),PMAXWS(10),PMINWS(10),BKGS(10),FACS(10)   VE3.3
     1 ,IPEDII(10),IPEL(10),IPES(10),PMIN(10)                           VE3.4
      COMMON /AMIX/ C(600)                                              COMM.5
      COMMON/FL/FO(20),FB(8),FM                                         COMM.6
      COMMON/FLS/FI(9)                                                  COMM.7
      COMMON/VRCON/ALX,ALY,ALZ,B0,BUFL,CEP,DT,DX(80),DXC,DY(80),DYC,    VE3.5
     1 DZ(80),DZC,EM0,EM6,ENF,GPX,GPY,GPZ,GX,GY,GZ,IBP1,IBP2,IBR,IBRED, VE3.6
     2 IBRIN,IBRST,IGOP(6),IJKMX,IJKNC,IJK2,IJP1K,IPL,IPR,ITER,I2JK2,   COMM.10
     * IKP2,IPARTF,IPLTF,ISFLG,RIBJBKH,LPR,DROU,                        COMM.11
     *IJKCON,ICON,JCON,                                                 COMM.12
     3 I2K2,JBP1,JBP2,JBR,JBRED,JBRIN,JBRST,JNC,JPA,JPF,J2NC,KBP1,KBP2, COMM.13
     4 KBR,KBRED,KBRIN,KBRST,KEP,KNC,KPR,KPT,KWA,KWB,KWF,KWL,KWR,KWT,   COMM.14
     5 K2NC,LABEL(8),LMPART,LNVRCM,LPARTC,NCTP,NCVTP(6),NCYC,NGOP,NOPI, COMM.15
     *NOCONC,                                                           COMM.16
     * OBLOC(1200),OBTYP(1200),NOB,NU,                                  VE3.7
     6 NOVP,NOVS,NPMX,NPRT,NTPE,NWPC,NWPP,PDX,PDY,PDZ,PI,PNFLM,RDT,     COMM.18
     7 RDX(80),RDY(80),RDZ(80),RRAN(20),SIGMA,TD,TD1,TD2,TFIN,TIMET,TIP,VE3.8
     8 TPL,TPLT,TPR,TPRT,TTD,TWIP,TWID,UI,UPI,VDI,VDO,VI,VNTP(6),VPI,   COMM.20
     9 VTP,WI,WPI,WRAN(20),X(80),XPCEN,Y(80),YPCEN,Z(80),ZPCEN          VE3.9
      COMMON /MODSET/ SCFLM(200)                                        COMM.22
      COMMON /SAFLM/ XCONV,ZCONV,FX1,FX2,FX3,FX4,FY1,FY2,FY3,FY4,       COMM.23
     1 FXL,FYH,PXL,PYH,IFLA(3),FFX3(75),FFY3(75)                        COMM.24
     2 ,ITCYC(3),XFC1(4),XFC2(4),YFC1(4),YFC2(4),PBTIM(2),XML,YML,ZML   COMM.25
     3 ,IFMID,IFTEST,IPLOPT,IPM(20),IPMM,IPPP,IPROJ,JPM(20),JPMM,JPPP,  COMM.26
     4 KPM(20),KPMM,KPPP,NEC,NMC,NPS,NPV,PEC(10),PMC(10),YCONV          COMM.27
     5 ,IFLAB,IFLIN,IFPNT,IFOPI,NCH,XFSP,XT,YFSP,YT                     COMM.28
      COMMON /ZLAST/ ZLAS                                               COMM.29
C                                                                       COMM.30
      EQUIVALENCE (A(1),U),(A(2),V),(A(3),W),(A(4),P),(A(5),CQ),        EQUIV.2
     1 (A(6),COF), (A(7),VOL)                                           EQUIV.3
      EQUIVALENCE (C(1),TA,QCON)                                        EQUIV.7
C                                                                       EQUIV.8
C ***** THIS SUBROUTINE VRIO HANDLES INPUT/OUTPUT                       VARP.1999
    1 FORMAT(1H1)                                                       VARP.2000
    2 FORMAT(1H1,2X,8H TIMET =,1PE12.5,8H CYCLE =,I6,5X,19H ITERATION NUVARP.2001
     1MBER =,I5,5X,10H DELTA T =,E12.5/3X,1HK,5X,1HI,5X,1HJ,12X,1HU,16X,VARP.2002
     2 1HV,16X,1HW,16X,1HP)                                             VARP.2003
    3 FORMAT(1H1,2X,1HK,5X,1HI,5X,1HJ,12X,1HU,16X,1HV,16X,1HW,16X,1HP)  VARP.2004
    4 FORMAT(1H ,1X,I4,2X,I4,2X,I4,4(5X,1PE12.5))                       VARP.2005
    5 FORMAT(1H1,2X,8H TIMET =,1PE12.5,8H CYCLE =,I6,5X,19H ITERATION NUVARP.2006
     1MBER =,I5,5X,10H DELTA T =,E12.5/3X,3HIJK,12X,2HDX,15X,2HDY,15X,  VARP.2007
     2 2HDZ,16X,1HX,16X,1HY,16X,1HZ)                                    VARP.2008
    6 FORMAT(1H1,3X,3HIJK,12X,2HDX,15X,2HDY,15X,2HDZ,16X,1HX,16X,1HY,   VARP.2009
     1 16X,1HZ)                                                         VARP.2010
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```
VRIO
             7 FORMAT(1H ,2X,I5,6(5X,1PE12.5))                                VARP.2011
               ENTRY VRIO1                                                     VARP.2012
       6       IF( LPR.EQ.1 .OR. IPARTF.GT.0 .OR. IPLTF.GT.0 ) GO TO 300       VARP.2013
      21       IF( LPR.EQ.2 ) VDO=9                                            VARP.2014
         C ***** THIS SECTION, 100-199 , PRINTS DATA ARRAYS ON THE LINE PRINTER VARP.2015
      24   100 LINS=0                                                          VARP.2016
      25       LINT=57                                                         VARP.2017
      26       LINC=LINT                                                       VARP.2018
      27       ASSIGN 110 TO KP1                                               VARP.2019
      30       KS=0                                                            VARP.2020
      31       GO TO 107                                                       VARP.2021
      32   103 LINS=LINS+1                                                     VARP.2022
      34       IF( LINS.LT.LINC ) GO TO KP1,( 110,190 )                        VARP.2023
      41       LINS=0                                                          VARP.2024
      42       LINC=LINT                                                       VARP.2025
      44       GO TO 107                                                       VARP.2026
      44   106 WRITE(VDO,2) TIMET,NCYC,ITER,DT                                 VARP.2027
      60       GO TO KP1,( 110,190 )                                           VARP.2028
      63   107 KS=KS+1                                                         VARP.2029
      65       IF( KS.EQ.1 ) GO TO 106                                         VARP.2030
      66       WRITE(VDO,3)                                                    VARP.2031
      71       GO TO KP1,( 110,190 )                                           VARP.2032
      74   110 JJ=1+(JBRST-2)*I2K2                                             VARP.2033
     101       DO 199 J=JBRST,JBRED,JBRIN                                      VARP.2034
     102       JJ=JJ+I2K2                                                      VARP.2035
     103       KK=(IBRST-2)*K2NC                                               VARP.2036
     107       DO 199 I=IBRST,IBRED,IBRIN                                      VARP.2037
     110       KK=KK+K2NC                                                      VARP.2038
     111       LWPC=(KBRST-2)*NWPC                                             VARP.2039
     115   120 DO 199 K=KBRST,KBRED,KBRIN                                      VARP.2040
     117       LWPC=LWPC+NWPC                                                  VARP.2041
     120       IJK=JJ+KK+LWPC                                                  VARP.2042
     123       ASSIGN 190 TO KP1                                               VARP.2043
     124       WRITE(VDO,4) K,I,J,U(IJK),V(IJK),W(IJK),P(IJK)                  VARP.2044
     152       GO TO 103                                                       VARP.2045
     153   190 CONTINUE                                                        VARP.2046
     153   199 CONTINUE                                                        VARP.2047
     163   200 IF( NCYC.GT.0 ) GO TO 300                                       VARP.2048
     166       INMAX=MAX0(IBP2,JBP2,KBP2)                                      VARP.2049
     173       LINS=0                                                          VARP.2050
     173       LINT=57                                                         VARP.2051
     174       LINC=LINT                                                       VARP.2052
     176       ASSIGN 210 TO KP1                                               VARP.2053
     177       KS=0                                                            VARP.2054
     200       GO TO 207                                                       VARP.2055
     200   203 LINS=LINS+1                                                     VARP.2056
     202       IF( LINS.LT.LINC ) GO TO KP1,(210,290)                          VARP.2057
     207       LINS=0                                                          VARP.2058
     210       LINC=LINT                                                       VARP.2059
     212   206 WRITE(VDO,5) TIMET,NCYC,ITER,DT                                 VARP.2060
     226       GO TO KP1,(210,290)                                             VARP.2061
     231   207 KS=KS+1                                                         VARP.2062
     233       IF( KS.EQ.1 ) GO TO 206                                         VARP.2063
     234       WRITE(VDO,6)                                                    VARP.2064
     237       GO TO KP1,(210,290)                                             VARP.2065
     242   210 DO 299 IN=1,INMAX                                               VARP.2066
```

```
 244          ASSIGN 290 TO KP1                                                  VARP.2067
 245          WRITE(YDD,7) IN,DX(IN),DY(IN),DZ(IN),X(IN),Y(IN),Z(IN)             VARP.2068
 274          GO TO 203                                                          VARP.2069
 275      290 CONTINUE                                                           VARP.2070
 275      299 CONTINUE                                                           VARP.2071
 300      300 YDD=6                                                              VARP.2072
 301          IF( PRFLM.LT.1 ) RETURN                                            VARP.2073
 304          CALL SECOND(I1)                                                    VARP.2074
 306      800 NOP=0                                                              VARP.2075
 307          IG1=IGOP(1)                                                        VARP.2076
 310          IG2=IGOP(2)                                                        VARP.2077
 312          IG3=IGOP(3)                                                        VARP.2078
 313          IG4=IGOP(4)                                                        VARP.2079
 315          IG5=IGOP(5)                                                        VARP.2080
 317      900 NOP=NOP + 1                                                        VARP.2081
 321          YI=.6                                                              VARP.2082
 322          IOPT=IGOP(NOP)                                                     VARP.2083
 324          GO TO( 1000,2000,3000,4000,                         99999),IOPT    VARP.2084
      C ***** THIS SECTION , 10000-1999 , PLOTS PARTICLE COORDINATES.            VARP.2085
      C ***** THIS SECTION , 10000-1999 , PLOTS PARTICLE COORDINATES.            VARP.2086
 334  1000    IFTEST=1                                                           VARP.2087
 335          IFMID=0                                                            VARP.2088
 336          IFPNT=1                                                            VARP.2089
 336          NPS=NPS                                                            VE3.218
 340          M=0                                                                VARP.2090
 340          IF( IPROJ.EQ.0 ) GO TO 1020                                        VARP.2091
 342  1020    CONTINUE                                                           VARP.2092
      C ***** THIS SECTION , 1030 , SETS CONSTANTS FOR IXK PLANE.                VARP.2093
 342          GO TO ( 1040,1030 ),JPPP                                           VARP.2094
 350  1030    IPLOPT=1                                                           VARP.2095
 351          ENCODE(30,9110,IFLB)                                               VARP.2096
 357          ASSIGN 1040 TO KPART                                               VARP.2097
 360          GO TO 1060                                                         VARP.2098
      C ***** THIS SECTION , 1040 , SETS CONSTANTS FOR IXJ PLANE.                VARP.2099
 361  1040    GO TO ( 1050,1042 ),KPPP                                           VARP.2100
 367  1042    IPLOPT=2                                                           VARP.2101
 370          ENCODE(30,9120,IFLB)                                               VARP.2102
 376          ASSIGN 1050 TO KPART                                               VARP.2103
 377          GO TO 1060                                                         VARP.2104
      C ***** THIS SECTION , 1050 , SETS CONSTANTS FOR JXK PLANE.                VARP.2105
 400  1050    IF( IPPP.EQ.1 ) GO TO 900                                          VARP.2106
 402  1052    IPLOPT=3                                                           VARP.2107
 403          ENCODE(30,9130,IFLB)                                               VARP.2108
 411          ASSIGN 900 TO KPART                                                VARP.2109
 412  1060    CALL FPLAN                                                         VARP.2110
 413          CALL FLMID                                                         VARP.2111
 414          M=M+1                                                              VARP.2112
 416          XT=0,02                                                            VARP.2113
 417          YT=0.52                                                            VARP.2114
 421          CALL FLMLAB                                                        VARP.2115
 422          XT=0.06                                                            VARP.2115
 423          YT=0.56                                                            VARP.2117
 425          ENCODE(15,9010,IFLB)                                               VARP.2118
 433          NCH=15                                                             VARP.2119
 434          CALL FLMLAB                                                        VARP.2120
 435          IFOPT=3                                                            VARP.2121
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   436          CALL FLMOPT                                                  VARP.2122
   437          LC=1-NWPP                                                    VARP.2123
   441   1100   DO 1199 L=1,NPS                                              VARP.2124
   443          LC=LC+NWPP                                                   VARP.2125
   444          IX=IFIX(XPC(LC)+EM6)                                         VARP.2126
   447          IY=IFIX(YPC(LC)+EM6)                                         VARP.2127
   451          IZ=IFIX(ZPC(LC)+EM6)                                         VARP.2128
   454          XP=X(IX-1) + DX(IX)*( XPC(LC)-FLOAT(IX) )                    VARP.2129
   461          YP=Y(IY-1) + DY(IY)*( YPC(LC)-FLOAT(IY) )                    VARP.2130
   466          ZP=Z(IZ-1) + DZ(IZ)*( ZPC(LC)-FLOAT(IZ) )                    VARP.2131
   474          GO TO ( 1120,1140,1160 ),IPLOPT                              VARP.2132
        C ***** THIS SECTION , 1120 , COMPUTES FILM COORDINATES FOR IXK PLANE.  VARP.2133
   503   1120   FPX=XP                                                       VARP.2134
   504          FPY=ZP                                                       VARP.2135
   506          GO TO 1180                                                   VARP.2136
        C ***** THIS SECTION , 1140 , COMPUTES FILM COORDINATES FOR IXJ PLANE.  VARP.2137
   507   1140   FPX=XP                                                       VARP.2138
   510          FPY=YP                                                       VARP.2139
   512          GO TO 1180                                                   VARP.2140
        C ***** THIS SECTION , 1160 , COMPUTES FILM COORDINATES FOR JXK PLANE.  VARP.2141
   513   1160   FPX=YP                                                       VARP.2142
   514          FPY=ZP                                                       VARP.2143
   516   1180   FX1=XFSP + (FPX-PXL)*XCONV                                   VARP.2144
   522          FY1=YFSP + (FPY-PYB)*YCONV                                   VARP.2145
   526          CALL FCTEST                                                  VARP.2146
   527   1199   CALL FLMPUT                                                  VARP.2147
   533          IF( M.LE.3 ) CALL FLMADV                                     VARP.2148
   536          GO TO KPART,( 900,1040,1050 )                                VARP.2149
        C ***** THIS SECTION , 2000-2999 , PLOTS MESH ZONES ON FILM.         VARP.2150
        C ***** THIS SECTION , 2000-2999 , PLOTS MESH ZONES ON FILM.         VARP.2151
   541    2000 IF(TIMET.GT.TPL) GO TO 900                                    VF3.219
   545          IEMID=1                                                      VARP.2153
   545          IFIEST=0                                                     VARP.2154
   546          M=0                                                          VARP.2155
   547          I1=2                                                         VARP.2156
   550          J1=2                                                         VARP.2157
   551          K1=2                                                         VARP.2158
   552          IF( IPROJ.EQ.0 ) GO TO 2020                                  VARP.2159
        C ***** THIS SECTION , 2020 , SETS CONSTANTS FOR I X K PLANE.        VARP.2160
   553   2020   GO TO( 2030,2022 ),JPPP                                      VARP.2161
   561   2022   IPLOPT=1                                                     VARP.2162
   562          ASSIGN 2030 TO KZONE                                         VARP.2163
   563          I2=IBP1                                                      VARP.2164
   564          J2=2                                                         VARP.2165
   565          K2=KBP1                                                      VARP.2166
   567          ENCODE(30,9110,IFLB)                                         VARP.2167
   575          GO TO 2100                                                   VARP.2168
        C ***** THIS SECTION , 2030 , SETS CONSTANTS FOR I X J PLANE.        VARP.2169
   576   2030   GO TO( 2040,2032 ),KPPP                                      VARP.2170
   604   2032   IPLOPT=2                                                     VARP.2171
   605          ASSIGN 2040 TO KZONE                                         VARP.2172
   606          I2=IBP1                                                      VARP.2173
   607          J2=JBP1                                                      VARP.2174
   611          K2=2                                                         VARP.2175
   612          ENCODE(30,9120,IFLB)                                         VARP.2176
   620          GO TO 2100                                                   VARP.2177
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          C ***** THIS SECTION , 2040 , SETS CONSTANTS FOR J X K PLANE.    VARP.2178
    621   2040  IF( IPPP.EQ.1 ) GO TO 900                                    VARP.2179
    623         IPLOPT=3                                                     VARP.2180
    624         I2=2                                                         VARP.2181
    625         J2=JBP1                                                      VARP.2182
    626         K2=KBP1                                                      VARP.2183
    630         ASSIGN 900 TO KZONE                                          VARP.2184
    631         ENCODE(30,9130,IFLB)                                         VARP.2185
    637   2100  CALL FPLAN                                                   VARP.2186
    640         CALL FLMID                                                   VARP.2187
    641         M=M+1                                                        VARP.2188
    643         XT=0.02                                                      VARP.2189
    644         YT=0.52                                                      VARP.2190
    646         CALL FLMLAB                                                  VARP.2191
    647         XT=0.16                                                      VARP.2192
    650         YT=0.56                                                      VARP.2193
    652         ENCODE(6,9020,IFLB)                                          VARP.2194
    660         NCH=6                                                        VARP.2195
    661         CALL FLMLAB                                                  VARP.2196
    662         IFOPT=4                                                      VARP.2197
    663         CALL FLMOPT                                                  VARP.2198
    664         IFOPT=5                                                      VARP.2199
    665         CALL FLMOPT                                                  VARP.2200
    666         DO 2299 J=J1,J2                                              VARP.2201
    670         DO 2299 I=I1,I2                                              VARP.2202
    672         DO 2299 K=K1,K2                                              VARP.2203
    674         GO TO( 2120,2140,2160 ),IPLOPT                               VARP.2204
          C ***** THIS SECTION , 2120 , COMPUTES FILM COORD FOR I X K PLANE.   VARP.2205
    705   2120  X1=X(I)                                                      VARP.2206
    706         X2=X(I)                                                      VARP.2207
    707         X3=X(I-1)                                                    VARP.2208
    711         X4=X(I-1)                                                    VARP.2209
    711         IX=I                                                         VARP.2210
    712         IXP1=I2                                                      VARP.2211
    714         Y1=Z(K-1)                                                    VARP.2212
    715         Y2=Z(K)                                                      VARP.2213
    717         Y3=Z(K)                                                      VARP.2214
    717         Y4=Z(K-1)                                                    VARP.2215
    720         IY=K                                                         VARP.2216
    722         IYP1=K2                                                      VARP.2217
    724         GO TO 2180                                                   VARP.2218
          C ***** THIS SECTION , 2140 , COMPUTES FILM COORD FOR I X J PLANE.   VARP.2219
    726   2140  X1=X(I)                                                      VARP.2220
    727         X2=X(I)                                                      VARP.2221
    730         X3=X(I-1)                                                    VARP.2222
    732         X4=X(I-1)                                                    VARP.2223
    732         IX=I                                                         VARP.2224
    733         IXP1=I2                                                      VARP.2225
    735         Y1=Y(J-1)                                                    VARP.2226
    736         Y2=Y(J)                                                      VARP.2227
    740         Y3=Y(J)                                                      VARP.2228
    740         Y4=Y(J-1)                                                    VARP.2229
    741         IY=J                                                         VARP.2230
    743         IYP1=J2                                                      VARP.2231
    745         GO TO 2180                                                   VARP.2232
          C ***** THIS SECTION , 2160 , COMPUTES FILM COORD FOR J X K PLANE.   VARP.2233
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     747   2160   X1=Y(J)                                                    VARP.2234
     750          X2=Y(J)                                                    VARP.2235
     751          X3=Y(J-1)                                                  VARP.2236
     753          X4=Y(J-1)                                                  VARP.2237
     753          IX=J                                                       VARP.2238
     754          IXP1=J2                                                    VARP.2239
     756          Y1=Z(K-1)                                                  VARP.2240
     757          Y2=Z(K)                                                    VARP.2241
     761          Y3=Z(K)                                                    VARP.2242
     761          Y4=Z(K-1)                                                  VARP.2243
     762          IY=K                                                       VARP.2244
     764          IYP1=K2                                                    VARP.2245
     766   2180   FX1=XFSP + (X1-FXL)*XCONV                                  VARP.2246
     772          FY1=YFSP + (Y1-FYB)*YCONV                                  VARP.2247
     776          FX2=XFSP + (X2-FXL)*XCONV                                  VARP.2248
    1002          FY2=YFSP + (Y2-FYB)*YCONV                                  VARP.2249
    1006          FX3=XFSP + (X3-FXL)*XCONV                                  VARP.2250
    1012          FY3=YFSP + (Y3-FYB)*YCONV                                  VARP.2251
    1016          FX4=XFSP + (X4-FXL)*XCONV                                  VARP.2252
    1022          FY4=YFSP + (Y4-FYB)*YCONV                                  VARP.2253
    1026          CALL FCTEST                                                VARP.2254
    1027          IF( IX.NE.IXP1 ) GO TO 2190                                VARP.2255
    1031          IFLIN=2                                                    VARP.2256
    1032          CALL FLMLIN                                                VARP.2257
    1033   2190   IF( IY.NE.IYP1 ) GO TO 2200                                VARP.2258
    1035          IFLIN=3                                                    VARP.2259
    1036          CALL FLMLIN                                                VARP.2260
    1037   2200   IFLIN=4                                                    VARP.2261
    1040          CALL FLMLIN                                                VARP.2262
    1041          IFLIN=5                                                    VARP.2263
    1042          CALL FLMLIN                                                VARP.2264
    1043   2299   CONTINUE                                                   VARP.2265
    1053          IF( M.LE.3 ) CALL FLMADV                                   VARP.2266
    1056          GO TO KZONE,( 900,2030,2040 )                              VARP.2267
           C ***** THIS SECTION , 3000-3999 , PLOTS VELOCITY VECTORS ON FILM.  VARP.2268
           C ***** THIS SECTION , 3000-3999 , PLOTS VELOCITY VECTORS ON FILM.  VARP.2269
    1061   3000   IFMTD=0                                                    VARP.2270
    1062          IFPNT=1                                                    VARP.2271
    1063          IFTFST=2                                                   VARP.2272
    1064          M=0                                                        VARP.2273
    1065          MMAX=IPMM + JPMM + KPMM                                    VARP.2274
    1067          IF( IPM(1).LT.1 ) MMAX=MMAX - 1                            VARP.2275
    1073          IF( JPM(1).LT.1 ) MMAX=MMAX - 1                            VARP.2276
    1076          IF( KPM(1).LT.1 ) MMAX=MMAX - 1                            VARP.2277
    1101          IF( IPROJ.EQ.0 ) GO TO 3050                                VARP.2278
           C ***** THIS SECTION , 3050 , SETS CONSTANTS FOR I X K PLANE.     VARP.2279
    1102   3050   IPLOPT=1                                                   VARP.2280
    1103          I1=2                                                       VARP.2281
    1104          I2=IMP1                                                    VARP.2282
    1105          K1=2                                                       VARP.2283
    1106          K2=KMP1                                                    VARP.2284
    1110          ASSIGN 3055 TO KVEC                                        VARP.2285
    1111          DO 3059 J4=1,JPMM                                          VARP.2286
    1113          IF( JPM(J4).LT.1 ) GO TO 3060                              VARP.2287
    1116          J1=JPM(J4)                                                 VARP.2288
    1117          J2=J1                                                      VARP.2289
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1121          ENCODE(30,9140,IFLB) J1                                   VARP.2290
1130          GO TO 3100                                                VARP.2291
1131   3055   CONTINUE                                                  VARP.2292
1131   3059   CONTINUE                                                  VARP.2293
       C ***** THIS SECTION , 3060 , SETS CONSTANTS FOR I X J PLANE.    VARP.2294
1134   3060   IPLOPT=2                                                  VARP.2295
1135          I1=2                                                      VARP.2296
1136          I2=IBP1                                                   VARP.2297
1137          J1=2                                                      VARP.2298
1140          J2=JBP1                                                   VARP.2299
1142          ASSIGN 3065 TO KVEC                                       VARP.2300
1143          DO 3069 K4=1,KPMM                                         VARP.2301
1145          IF( KPM(K4).LT.1 ) GO TO 3070                             VARP.2302
1150          K1=KPM(K4)                                                VARP.2303
1151          K2=K1                                                     VARP.2304
1153          ENCODE(30,9150,IFLB) K1                                   VARP.2305
1162          GO TO 3100                                                VARP.2306
1163   3065   CONTINUE                                                  VARP.2307
1163   3069   CONTINUE                                                  VARP.2308
       C ***** THIS SECTION , 3070 , SETS CONTANTS FOR J X K PLANE.     VARP.2309
1166   3070   IPLOPT=3                                                  VARP.2310
1167          J1=2                                                      VARP.2311
1170          J2=JBP1                                                   VARP.2312
1171          K1=2                                                      VARP.2313
1172          K2=KBP1                                                   VARP.2314
1174          ASSIGN 3075 TO KVEC                                       VARP.2315
1175          DO 3079 I4=1,IPMM                                         VARP.2316
1177          IF( IPM(I4).LT.1 ) GO TO 900                              VARP.2317
1202          I1=IPM(I4)                                                VARP.2318
1203          I2=I1                                                     VARP.2319
1205          ENCODE(30,9160,IFLB) I1                                   VARP.2320
1214          GO TO 3100                                                VARP.2321
1215   3075   CONTINUE                                                  VARP.2322
1215   3079   CONTINUE                                                  VARP.2323
1220          GO TO 900                                                 VARP.2324
1220   3100   CALL FPLAN                                                VARP.2325
1221          CALL FLMID                                                VARP.2326
1222          N=M + 1                                                   VARP.2327
1224          XT=0.02                                                   VARP.2328
1225          YT=0.52                                                   VARP.2329
1227          CALL FLMLAB                                               VARP.2330
1230          XT=0.06                                                   VARP.2331
1231          YT=0.56                                                   VARP.2332
1233          ENCODE(10,9030,IFLB)                                      VARP.2333
1241          NCH=10                                                    VARP.2334
1242          CALL FLMLAB                                               VARP.2335
1243          IFOPT=3                                                   VARP.2336
1244          CALL FLMOPT                                               VARP.2337
1245          IFLIN=2                                                   VARP.2338
1246   3200   JJ=1 + (J1-2)*I2K2                                        VARP.2339
1253          DO 3299 J=J1,J2                                           VARP.2340
1255          JJ=JJ + I2K2                                              VARP.2341
1256          KK=(I1-2)*K2NC                                            VARP.2342
1261          YAV=.5*( Y(J-1)+Y(J) )                                    VARP.2343
1265          DO 3299 I=I1,I2                                           VARP.2344
1270          KK=KK + K2NC                                              VARP.2345
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VRIO
   1271             LWPC=(K1-2)*NWPC                                                 VARP.2346
   1274             XAV=.5*( X(I-1)+X(I) )                                            VARP.2347
   1300             DO 3299 K=K1,K2                                                   VARP.2348
   1303             LWPC=LWPC + NWPC                                                  VARP.2349
   1304             IJK=JJ+KK+LWPC                                                    VARP.2350
   1307             IMJK=IJK - K2MC                                                   VARP.2351
   1310             IJMK=IJK - I2K2                                                   VARP.2352
   1312             IJKM=IJK - NWPC                                                   VARP.2353
   1314             ZAV=.5*( Z(K-1)+Z(K) )                                            VARP.2354
   1317             GO TO( 3220,3240,3260 ),IPLOPT                                    VARP.2355
          C ***** THIS SECTION , 3220 , COMPUTES FILM COORD FOR I X K PLANE.          VARP.2356
   1327   3220      UAV=.5*( U(IMJK)+U(IJK) )                                         VARP.2357
   1332             X14A=XAV                                                          VARP.2358
   1334             VAV=.5*( W(IJKM)+W(IJK) )                                         VARP.2359
   1337             Y12A=ZAV                                                          VARP.2360
   1341             GO TO 3280                                                        VARP.2361
          C ***** THIS SECTION , 3240 , COMPUTES FILM COORD FOR I X J PLANE.          VARP.2362
   1343   3240      UAV=.5*( U(IMJK)+U(IJK) )                                         VARP.2363
   1346             X14A=XAV                                                          VARP.2364
   1350             VAV=.5*( V(IJMK)+V(IJK) )                                         VARP.2365
   1353             Y12A=YAV                                                          VARP.2366
   1355             GO TO 3280                                                        VARP.2367
          C ***** THIS SECTION , 3260 , COMPUTES FILM COORD FOR J X K PLANE.          VARP.2368
   1357   3260      UAV=.5*( V(IJMK)+V(IJK) )                                         VARP.2369
   1362             X14A=YAV                                                          VARP.2370
   1364             VAV=.5*( W(IJKM)+W(IJK) )                                         VARP.2371
   1367             Y12A=ZAV                                                          VARP.2372
   1371   3280      FX1=XFSP + (X14A-FXL)*XCONV                                       VARP.2373
   1375             FY1=YFSP + (Y12A-FYB)*YCONV                                       VARP.2374
   1401             FX2=XFSP + (X14A+UAV*DROU-FXL)*XCONV                              VARP.2375
   1407             FY2=YFSP + (Y12A+VAV*DROU-FYB)*YCONV                              VARP.2376
   1415             CALL ECTEST                                                       VARP.2377
   1416             CALL FLMPNT                                                       VARP.2378
   1417             CALL FLMLIN                                                       VARP.2379
   1420   3299      CONTINUE                                                          VARP.2380
   1430             IF( M.LE.MMAX ) CALL FLMADV                                       VARP.2381
   1433             GO TO KVEC,( 3055,3065,3075 )                                     VARP.2382
          C ***** THIS SECTION , 4000-4999 , PLOTS CONTOURS ON FILM.                  VARP.2383
          C ***** THIS SECTION , 4000-4999 , PLOTS CONTOURS ON FILM.                  VARP.2384
   1436   4000      IFMID=0                                                           VARP.2385
   1437             IFPNT=2                                                           VARP.2386
   1440             IFTEST=2                                                          VARP.2387
   1441             M=0                                                               VARP.2388
   1442             MMAX=IPMM + JPMM + KPMM                                           VARP.2389
   1444             IF( IPM(1).LT.1 ) MMAX=MMAX - 1                                   VARP.2390
   1450             IF( JPM(1).LT.1 ) MMAX=MMAX - 1                                   VARP.2391
   1453             IF( KPM(1).LT.1 ) MMAX=MMAX - 1                                   VARP.2392
   1456             IF( IPROJ.EQ.0 ) GO TO 4030                                       VARP.2393
          C ***** THIS SECTION , 4030 , SETS CONSTANTS FOR I X K PLANE.               VARP.2394
   1457   4030      IPLOPT=1                                                          VARP.2395
   1460             I1=2                                                              VARP.2396
   1461             I2=IBP1                                                           VARP.2397
   1462             I1P=I1+1                                                          VARP.2398
   1464             I2M=I2-1                                                          VARP.2399
   1465             K1=2                                                              VARP.2400
   1466             K2=KBP1                                                           VARP.2401
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      K1P=K1+1                                                          VARP.2402
      K2M=K2-1                                                          VARP.2403
      ASSIGN 4035 TO KCON                                               VARP.2404
      DO 4039 J4=1,JPMM                                                 VARP.2405
      IF( JPM(J4).LT.1 ) GO TO 4040                                     VARP.2406
      J1=JPM(J4)                                                        VARP.2407
      J2=J1P=J2M=J1                                                     VARP.2408
      ENCODE(30,9140,IFLB) J1                                           VARP.2409
      GO TO 4080                                                        VARP.2410
 4035 CONTINUE                                                          VARP.2411
 4039 CONTINUE                                                          VARP.2412
C ***** THIS SECTION , 4040 , SETS CONSTANTS FOR I X J PLANE.            VARP.2413
 4040 IPLOPT=2                                                          VARP.2414
      I1=2                                                              VARP.2415
      I2=IBP1                                                           VARP.2416
      I1P=I1+1                                                          VARP.2417
      I2M=I2-1                                                          VARP.2418
      J1=2                                                              VARP.2419
      J2=JHP1                                                           VARP.2420
      J1P=J1+1                                                          VARP.2421
      J2M=J2-1                                                          VARP.2422
      ASSIGN 4045 TO KCON                                               VARP.2423
      DO 4049 K4=1,KPMM                                                 VARP.2424
      IF( KPM(K4).LT.1 ) GO TO 4050                                     VARP.2425
      K1=KPM(K4)                                                        VARP.2426
      K2=K1P=K2M=K1                                                     VARP.2427
      ENCODE(30,9150,IFLB) K1                                           VARP.2428
      GO TO 4080                                                        VARP.2429
 4045 CONTINUE                                                          VARP.2430
 4049 CONTINUE                                                          VARP.2431
C ***** THIS SECTION , 4050 , SETS CONTANTS FOR J X K PLANE.             VARP.2432
 4050 IPLOPT=3                                                          VARP.2433
      J1=2                                                              VARP.2434
      J2=JHP1                                                           VARP.2435
      J1P=J1+1                                                          VARP.2436
      J2M=J2-1                                                          VARP.2437
      K1=2                                                              VARP.2438
      K2=KBP1                                                           VARP.2439
      K1P=K1+1                                                          VARP.2440
      K2M=K2-1                                                          VARP.2441
      ASSIGN 4055 TO KCON                                               VARP.2442
      DO 4059 I4=1,IPMM                                                 VARP.2443
      IF( IPM(I4).LT.1 ) GO TO 900                                      VARP.2444
      I1=IPM(I4)                                                        VARP.2445
      I2=I1P=I2M=I1                                                     VARP.2446
      ENCODE(30,9160,IFLB) I1                                           VARP.2447
      GO TO 4080                                                        VARP.2448
 4055 CONTINUE                                                          VARP.2449
 4059 CONTINUE                                                          VARP.2450
      GO TO 900                                                         VARP.2451
 4080 DO 4799 MV=1,NOVP                                                 VARP.2452
      CALL FPLAN                                                        VARP.2453
      CALL FLMID                                                        VARP.2454
      M=M+1                                                             VARP.2455
      XT=0.02                                                           VARP.2456
      YT=0.52                                                           VARP.2457
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VRID
  1633         CALL FLMLAB                                                  VARP.2458
  1635         VTF=VNTP(MV)                                                 VARP.2459
  1636         NCTP=NCVTP(MV)                                               VARP.2460
  1640         GO TO ( 4082,4084,4086,4088 ),VTP                            VARP.2461
  1650   4082  ENCODE(30,9040,IFLB)                                         VARP.2462
  1656         GO TO 4090                                                   VARP.2463
  1657   4084  ENCODE(30,9050,IFLB)                                         VARP.2464
  1665         GO TO 4090                                                   VARP.2465
  1666   4086  ENCODE(30,9060,IFLB)                                         VARP.2466
  1674         GO TO 4090                                                   VARP.2467
  1675   4088  ENCODE(30,9170,IFLB)                                         VARP.2468
  1703   4090  NCH=30                                                       VARP.2469
  1704         YT=0.56                                                      VARP.2470
  1706         CALL FLMLAB                                                  VARP.2471
        C ***** THIS SECTION , 4100-4199 , TRANSFERS CONTOUR VARIABLE TO CQ VARP.2472
        C ***** ARRAY AND COMPUTES QMX,QMN.                                 VARP.2473
  1707   4100  JJ=1 + (J1-2)*I2K2                                           VARP.2474
  1713         ICQ=0                                                        VARP.2475
  1714         DO 4189 J=J1,J2                                              VARP.2476
  1716         JJ=JJ + I2K2                                                 VARP.2477
  1717         KK=(I1-2)*K2NC                                               VARP.2478
  1723         DO 4189 I=I1,I2                                              VARP.2479
  1724         KK=KK + K2NC                                                 VARP.2480
  1725         LWPC=(K1-2)*NWPC                                             VARP.2481
  1731         DO 4189 K=K1,K2                                              VARP.2482
  1732         LWPC=LWPC + NWPC                                             VARP.2483
  1733         IJK=JJ+KK+LWPC                                               VARP.2484
  1736         IMJK=IJK - K2NC                                              VARP.2485
  1737         IJMK=IJK - I2K2                                              VARP.2486
  1741         IJKM=IJK - NWPC                                              VARP.2487
  1743         ICQ=ICQ+1                                                    VARP.2488
  1745         GO TO ( 4120,4130,4140,4150 ),VTP                            VARP.2489
  1755   4120  IF(NOCUNC.GE.1) GO TO 4160                                   VARP.2490
  1760         CQ(IJK)=P(IJK)                                               VARP.2491
  1762         GO TO 4160                                                   VARP.2492
  1762   4130  CQ(IJK)=.5*( U(IMJK)+U(IJK) )                                VARP.2493
  1766         GO TO 4160                                                   VARP.2494
  1767   4140  CQ(IJK)=.5*( W(IJKM)+W(IJK) )                                VARP.2495
  1773         GO TO 4160                                                   VARP.2496
  1774   4150  CQ(IJK)=.5*( V(IJMK)+V(IJK) )                                VARP.2497
  2000   4160  IF( ICQ.EQ.1 ) QMX=QMN=CQ(IJK)                               VARP.2498
  2006         QMX=AMAX1(QMX,CQ(IJK))                                       VARP.2499
  2012         QMN=AMIN1(QMN,CQ(IJK))                                       VARP.2500
  2015   4189  CONTINUE                                                     VARP.2501
  2024         DELQ=(QMX-QMN)/FLOAT(NCTP+1)                                 VARP.2502
  2030         IF( ABS(DELQ) .LT. 1.E-20 ) GO TO 4798                       VARP.2503
  2033         ENCODE(30,9070,IFLB) QMX,QMN                                 VARP.2504
  2045         YT=0.50                                                      VARP.2505
  2047         CALL FLMLAB                                                  VARP.2506
  2050         YT=YT-.02                                                    VARP.2507
  2052         ENCODE(30,9080,IFLB) DELQ                                    VARP.2508
  2062         CALL FLMLAB                                                  VARP.2509
        C ***** THIS SECTION , 4200-4399 , COMPUTES CONTOUR VALUES AND PLOTS VARP.2510
        C ***** ON FILM.                                                    VARP.2511
  2063   4200  DO 4499 L=1,NCTP                                             VARP.2512
  2065         QQ=QCON(L)=QMN+FLOAT(L)*DELQ                                 VARP.2513
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      C ***** THIS SECTION , 4210-4219 , FLAGS EACH CONTOUN CELL.             VARP.2514
      C ***** COF=0 IF QQ LESS THAN CQ , COF=1 IF QQ EQ OR GREATER THAN CQ.   VARP.2515
 2071 4210  JJ=1 + (J1-2)*I2K2                                                VARP.2516
 2076       DO 4219 J=J1,J2                                                   VARP.2517
 2077       JJ=JJ+I2K2                                                        VARP.2518
 2100       KK=(I1-2)*K2NC                                                    VARP.2519
 2104       DO 4219 I=I1,I2                                                   VARP.2520
 2105       KK=KK + K2NC                                                      VARP.2521
 2106       LWPC=(K2-2)*NWPC                                                  VARP.2522
 2112       DO 4219 K=K1,K2                                                   VARP.2523
 2114       LWPC=LWPC + NWPC                                                  VARP.2524
 2115       IJK=JJ + KK + LWPC                                                VARP.2525
 2120       COF(IJK)=1                                                        VARP.2526
 2122       IF( CQ(IJK).LT.QQ ) COF(IJK)=0                                    VARP.2527
 2125 4219  CONTINUF                                                          VARP.2528
      C ***** THIS SECTION , 4250-4399 , COMPUTES AND PLOTS CONTOUR LINES.    VARP.2529
 2135 4250  JJ=1 + (J1P-2)*I2K2                                               VARP.2530
 2142       DO 4399 J=J1P,J2M                                                 VARP.2531
 2143       JJ=JJ + I2K2                                                      VARP.2532
 2144       KK=(I1P-2)*K2NC                                                   VARP.2533
 2150       GO TO( 4260,4252,4254 ),IPLOPT                                    VARP.2534
      C ***** THIS SECTION , 4252 , SETS CONSTANTS FOR I X J PLANE.           VARP.2535
 2161 4252  Y1=Y(J-1)                                                         VARP.2536
 2162       Y2=Y(J)                                                           VARP.2537
 2163       Y3=Y2                                                             VARP.2538
 2164       Y4=Y1                                                             VARP.2539
 2165       Y5=Y2                                                             VARP.2540
 2166       Y6=Y1                                                             VARP.2541
 2166       Y7=Y(J-2)                                                         VARP.2542
 2170       Y8=Y7                                                             VARP.2543
 2170       Y9=Y7                                                             VARP.2544
 2171       IY=J                                                              VARP.2545
 2173       GO TO 4260                                                        VARP.2546
      C ***** THIS SECTION , 4254 , SETS CONSTANTS FOR J X K PLANE.           VARP.2547
 2176 4254  X1=Y(J)                                                           VARP.2548
 2177       X2=X1                                                             VARP.2549
 2177       X3=Y(J-1)                                                         VARP.2550
 2201       X4=X3                                                             VARP.2551
 2201       X5=Y(J-2)                                                         VARP.2552
 2203       X6=X5                                                             VARP.2553
 2203       X7=X5                                                             VARP.2554
 2204       X8=X3                                                             VARP.2555
 2206       X9=Y1                                                             VARP.2556
 2207       IX=J                                                              VARP.2557
 2211 4260  DO 4399 I=I1P,I2M                                                 VARP.2558
 2213       KK=KK + K2NC                                                      VARP.2559
 2214       LWPC=(K1P-2)*NWPC                                                 VARP.2560
 2220       GO TO ( 4262,4262,4270 ),IPLOPT                                   VARP.2561
      C ***** THIS SECTION , 4262 , SETS CONSTANTS FOR I X K OR I X J PLANE.  VARP.2562
 2231 4262  X1=X(I)                                                           VARP.2563
 2232       X2=X1                                                             VARP.2564
 2232       X3=X(I-1)                                                         VARP.2565
 2234       X4=X3                                                             VARP.2566
 2234       X5=X(I-2)                                                         VARP.2567
 2236       X6=X5                                                             VARP.2568
 2236       X7=X5                                                             VARP.2569
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VBIU
    2237          X8=X3                                                        VARP.2570
    2241          X9=X1                                                        VARP.2571
    2242          IX=1                                                         VARP.2572
    2244   4270   DO 4399 K=K1P,K2M                                            VARP.2573
    2246          LMPC=LMPC + NMPC                                             VARP.2574
    2247          IJK=JJ + KK + LMPC                                           VARP.2575
    2252          IMJK=IJK - K2MC                                              VARP.2576
    2253          IJKM=IJK - LMPC                                              VARP.2577
    2254          IMJKM=IJKM - K2MC                                            VARP.2578
    2256          GO TO ( 4272,4280,4272 ),IPLOPT                              VARP.2579
           C ***** THIS SECTION , 4272 , SETS CONSTANTS FOR I X K OR J X K PLANE.  VARP.2580
    2267   4272   Y1=Z(K-1)                                                    VARP.2581
    2270          Y2=Z(K)                                                      VARP.2582
    2271          Y3=Y2                                                        VARP.2583
    2272          Y4=Y1                                                        VARP.2584
    2273          Y5=Y2                                                        VARP.2585
    2274          Y6=Y1                                                        VARP.2586
    2274          Y7=Z(K-2)                                                    VARP.2587
    2276          Y8=Y7                                                        VARP.2588
    2276          Y9=Y7                                                        VARP.2589
    2277          IY=K                                                         VARP.2590
    2301   4280   IF1=CQF(IJKM)                                                VARP.2591
    2303          IF2=CQF(IJK)                                                 VARP.2592
    2305          IF3=CQF(IMJK)                                                VARP.2593
    2307          IF4=CQF(IMJKM)                                               VARP.2594
    2311          IFT=IF1+IF2+IF3+IF4                                          VARP.2595
           C ***** THIS CHECKS TO SEE WHETHER A CONTOUR VARIABLE NEEDS A SHIFT.   VARP.2596
    2316          IF( IFT.GT.3 .OR. IFT.LT.1 ) GO TO 4398                      VARP.2597
    2326          Q1=CQ(IJKM)                                                  VARP.2598
    2327          Q2=CQ(IJK)                                                   VARP.2599
    2331          Q3=CQ(IMJK)                                                  VARP.2600
    2332          Q4=CQ(IMJKM)                                                 VARP.2601
           C ***** THIS SECTION CALCULATES VOLUME CONSTANTS.                   VARP.2602
    2334          QBP=.25*(Q1+Q2+Q3+Q4)                                        VARP.2603
    2337          XI1=.5*(X1+X9-X4-X8)                                         VARP.2604
    2344          XI2=.5*(X2+X1-X3-X4)                                         VARP.2605
    2350          XI3=.5*(X3+X4-X5-X6)                                         VARP.2606
    2354          XI4=.5*(X4+X8-X6-X7)                                         VARP.2607
    2360          XK1=.5*(X1+X4-X8-X9)                                         VARP.2608
    2364          XK2=.5*(X2+X3-X4-X1)                                         VARP.2609
    2370          XK3=.5*(X3+X5-X6-X4)                                         VARP.2610
    2374          XK4=.5*(X4+X6-X7-X8)                                         VARP.2611
    2400          YI1=.5*(Y1+Y9-Y4-Y8)                                         VARP.2612
    2405          YI2=.5*(Y2+Y1-Y3-Y4)                                         VARP.2613
    2411          YI3=.5*(Y3+Y4-Y5-Y6)                                         VARP.2614
    2415          YI4=.5*(Y4+Y8-Y6-Y7)                                         VARP.2615
    2421          YK1=.5*(Y1+Y4-Y8-Y9)                                         VARP.2616
    2425          YK2=.5*(Y2+Y3-Y4-Y1)                                         VARP.2617
    2431          YK3=.5*(Y3+Y5-Y6-Y4)                                         VARP.2618
    2435          YK4=.5*(Y4+Y6-Y7-Y8)                                         VARP.2619
           C ***** THIS SECTION CALCULATES CONTOUR CELL VOLUME - QX,QZ.        VARP.2620
    2441          VOL=.25*( XI1*YK1-XK1*YI1 + XI2*YK2-XK2*YI2 + XI3*YK3-XK3*YI3  VARP.2621
                 1        + XI4*YK4-XK4*YI4 )                                  VARP.2622
    2460          QX1=Q1*(YK1+YI1)                                             VARP.2623
    2462          QX2=Q2*(YK2-YI2)                                             VARP.2624
    2465          QX3=Q3*(YI3+YK3)                                             VARP.2625
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2467          QX4=Q4*(YK4-YI4)                                          VARP.2626
2472          QK1=Q1*(XI1+XK1)                                          VARP.2627
2474          QK2=Q2*(XK2-XI2)                                          VARP.2628
2477          QK3=Q3*(XI3+XK3)                                          VARP.2629
2501          QK4=Q4*(XK4-XI4)                                          VARP.2630
2504          QX=.5*(QX1+QX2-QX3-QX4)                                   VARP.2631
2511          QZ=.5*(QK3+QK4-QK1-QK2)                                   VARP.2632
2515          IF(QX.EQ.0.0 .AND. QZ .EQ.0.0) GO TO 4285                 VARP.2633
2524          QRS=1./(QX*QX+QZ*QZ)                                      VARP.2634
2526          GO TO 4290                                                VARP.2635
2527     4285 QRS=0.0                                                   VARP.2636
        C ***** THIS SECTION CALCULATES SHIFTED VERTEX POSITION.        VARP.2637
2532     4290 DELX= (QG-QBR) *VOL*QX*QRS                                VARP.2638
2535          DELZ=(QG-QBR)*VOL*QZ*QRS                                  VARP.2639
2537          X4= X4+DELX                                               VARP.2640
2541          Y4= Y4+DELY                                               VARP.2641
        C ***** THIS SECTION PLOTS THE CONTOUR SHIFT ON FILM.           VARP.2642
2543          FX2=XFSP + (X4-FXL)*XCONV                                 VARP.2643
2547          FY2=YFSP + (Y4-FYB)*YCONV                                 VARP.2644
2553          CALL FCTEST                                               VARP.2645
2554          IF( L.GT.1 .AND. L.LT.NCTP ) GO TO 4340                   VARP.2646
2564          IFOPT=6                                                   VARP.2647
2565          CALL FLMOPT                                               VARP.2648
2566          IFOPT=7                                                   VARP.2649
2567          IF( L.EQ.NCTP ) IFOPT=8                                   VARP.2650
2572          CALL FLMOPT                                               VARP.2651
2573          CALL FLMPNT                                               VARP.2652
2574          IFOPT=3                                                   VARP.2653
2575          CALL FLMOPT                                               VARP.2654
2576     4340 IF( IX.EQ.3 ) GO TO 4360                                  VARP.2655
        C ***** THIS SECTION PLOTS LEFT CONTOUR SEGMENT.                VARP.2656
2600          IF( IF3.EQ.IF4 ) GO TO 4350                               VARP.2657
2603          FX3=FFX3(K)                                               VARP.2658
2604          FY3=FFY3(K)                                               VARP.2659
2606          IFLIN=3                                                   VARP.2660
2607          CALL FLMLIN                                               VARP.2661
        C ***** THIS SECTION PLOTS BOTTOM CONTOUR SEGMENT.              VARP.2662
2610     4350 IF( IF1.EQ.IF4 ) GO TO 4380                               VARP.2663
2612          IF( IY.LT.4 ) GO TO 4380                                  VARP.2664
2615          IFLIN=6                                                   VARP.2665
2616          CALL FLMLIN                                               VARP.2666
2617          GO TO 4380                                                VARP.2667
2620     4360 IF( IY.GT.3 ) GO TO 4350                                  VARP.2668
2625     4380 FFX3(K)=FX2                                               VARP.2669
2626          FFY3(K)=FY2                                               VARP.2670
2630          FX1=FX2                                                   VARP.2671
2630          FY1=FY2                                                   VARP.2672
2632     4398 CONTINUE                                                  VARP.2673
2632     4399 CONTINUE                                                  VARP.2674
2642     4499 CONTINUE                                                  VARP.2675
2644          XT=.02                                                    VARP.2676
2646          DO 4519 LF=1,NCTP,2                                       VARP.2677
2647          YT=YT-.02                                                 VARP.2678
2651          ENCODE(30,9090,IFLB) QCON(LF),QCON(LF+1)                  VARP.2679
2664          CALL FLMLAB                                               VARP.2680
2665     4519 CONTINUE                                                  VARP.2681
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VRIU.
    2670   4798 IF(M.LE.MMAX) CALL FLMADV                                   VARP.2682
    2670   4799 CONTINUE                                                    VARP.2683
    2677        GO TO KCON,( 4035,4045,4055 )                               VARP.2684
           C ***** FORMATS ***** FORMATS ***** FORMATS.                     VARP.2685
           9000 FORMAT(7H TIME =,1PE11.4,7H NCYC =,I5)                      VARP.2686
           9010 FORMAT(15H PARTICLE PLOT )                                  VARP.2687
           9020 FORMAT(6H ZONES)                                            VARP.2688
           9030 FORMAT(18H VELOCITY VECTORS )                               VARP.2689
           9040 FORMAT(30H        PRESSURE CONTOURS       )                 VARP.2690
           9050 FORMAT(30H        U VELOCITY CONTOURS     )                 VARP.2691
           9060 FORMAT(30H        W VELOCITY CONTOURS     )                 VARP.2692
           9070 FORMAT(4HQMAX,1PE11.4,4HQMIN,E11.4)                         VARP.2693
           9080 FORMAT(15HQ(K)=QMN+K*DQ  ,4H DQ=,1PE11.4)                   VARP.2694
           9090 FORMAT(3H U=,1PE12.5,3H W=,E12.5)                           VARP.2695
           9100 FORMAT(1H ,21H TIME IN FILM PLOT = ,1PE12.5)                VARP.2696
           9110 FORMAT(30HJ PLANE CONST.,I-HORZ.,K-VERT.)                   VARP.2697
           9120 FORMAT(30HK PLANE CONST.,I-HORZ.,J-VERT.)                   VARP.2698
           9130 FORMAT(30HI PLANE CONST.,J-HORZ.,K-VERT.)                   VARP.2699
           9140 FORMAT(9HJ PLANE =,I3,3X,15HI-HORZ.,K-VERT.)                VARP.2700
           9150 FORMAT(9HK PLANE =,I3,3X,15HI-HORZ.,J-VERT.)                VARP.2701
           9160 FORMAT(9HI PLANE =,I3,3X,15HJ-HORZ.,K-VERT.)                VARP.2702
           9170 FORMAT(30H        V VELOCITY CONTOURS     )                 VARP.2703
    2702  99999 CALL SECOND(T2)                                             VARP.2704
    2704        T3=T2-T1                                                    VARP.2705
    2706        WRITE(6,9100) T3                                            VARP.2706
    2714        IGOP(1)=IG1                                                 VARP.2707
    2715        IGOP(2)=IG2                                                 VARP.2708
    2717        IGOP(3)=IG3                                                 VARP.2709
    2720        IGOP(4)=IG4                                                 VARP.2710
    2722        IGOP(5)=IG5                                                 VARP.2711
    2724        RETURN                                                      VARP.2712
    2724        END                                                         VARP.2713


SUBPROGRAM LENGTH

03561

FUNCTION ASSIGNMENTS

STATEMENT ASSIGNMENTS
1      - 002730   2      - 002732   3      - 002752   4      - 002761   5      - 002766   6      - 003007
7      - 003020   100    - 000025   103    - 000033   106    - 000045   107    - 000060   110    - 000075
120    - 000116   190    - 000154   199    - 000154   200    - 000164   203    - 000201   206    - 000213
207    - 000232   210    - 000243   290    - 000276   299    - 000276   300    - 000301   800    - 000307
900    - 000320   1000   - 000335   1020   - 000343   1030   - 000351   1040   - 000362   1042   - 000370
1050   - 000401   1052   - 000403   1060   - 000413   1100   - 000442   1120   - 000504   1140   - 000510
1160   - 000514   1180   - 000517   2000   - 000542   2020   - 000550   2022   - 000562   2030   - 000577
2032   - 000605   2080   - 000622   2100   - 000640   2120   - 000704   2140   - 000725   2160   - 000746
2180   - 000767   2190   - 001034   2200   - 001040   3000   - 001062   3050   - 001103   3055   - 001132
3059   - 001132   3060   - 001135   3065   - 001164   3069   - 001164   3070   - 001167   3075   - 001216
3079   - 001216   3100   - 001221   3200   - 001247   3220   - 001327   3240   - 001343   3260   - 001357
3280   - 001372   4000   - 001437   4030   - 001460   4035   - 001516   4039   - 001516   4040   - 001521
4045   - 001557   4049   - 001557   4050   - 001562   4055   - 001620   4059   - 001620   4080   - 001623
4082   - 001651   4084   - 001660   4086   - 001667   4088   - 001676   4090   - 001704   4100   - 001710
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                SUBROUTINE VRTAP                                                VARP.2714
                LARGE PTM(30000)                                                VE3.220
                INTEGER F,ERF,VDI,VDO,BUFL,PYML,PXML,CPRT,VNIP,VTP,PF,ID,TO1,TO2, INREAL.2
              1 PRFLM,CQF,SHIFT,OBLOC,OBTYP,FI,FO,FB,EM,OBTYPL                  INREAL.3
                REAL NU                                                         INREAL.4
          C                                                                     INREAL.5
                DIMENSION U(1),V(1),W(1),P(1),CQ(1),CQF(1)                      DIMEN.2
              1 ,VOL(1)                                                         DIMEN.3
                DIMENSION SPEC(10),TSP(10)                                      VE3.1
                DIMENSION TA(1),QCON(1)                                         DIMEN.6
          C                                                                     DIMEN.7
                COMMON/VHCUM/A(36000)                                           VE3.2
                COMMON/CONCEN/ NBPS(10),PMAXWS(10),PMINWS(10),BKGB(10),FACS(10) VE3.3
              1 ,IPEDIT(10),IPEL(10),IPES(10),PMIN(10)                          VE3.4
                COMMON /AMIX/ C(600)                                            COMM.5
                COMMON/EL/FO(20),FB(8),FM                                       COMM.6
                COMMON/FLS/FI(9)                                                COMM.7
                COMMON/VHCOM/ALX,ALY,ALZ,B0,BUFL,CEP,DT,DX(80),DXC,DY(80),DYC,  VE3.5
              1 DZ(80),DZC,EM0,EM6,ERF,GPX,GPY,GPZ,GX,GY,GZ,IHP1,IHP2,IBR,IBRED, VE3.6
              2 IBRIN,IBRST,IGOP(6),IJKMX,IJKNC,IJK2,IJP1K,IPL,IPR,IIER,I2JK2,  COMM.10
              * IHP2,IPARIF,IPLTF,ISFLG,RIHJBKH,LPR,ORDU,                       COMM.11
              *IJKCON,ICOM,JCON,                                                COMM.12
              3 I2K2,JBP1,JBP2,JBR,JBRED,JBRIN,JBRST,JNC,JPA,JPF,J2NC,KBP1,KBP2, COMM.13
              4 KBR,KBRED,KBRIN,KBRST,KEP,KNC,KPB,KPT,KWA,KWB,KWF,KWL,KWR,KKT,  COMM.14
              5 K2NC,LABEL(8),LAPART,LNVRCM,LPARTC,NCTP,NCVIP(6),NCYC,NGOP,NOPI, COMM.15
              *NOCONC,                                                          COMM.16
              * OBLOC(1200),OBTYP(1200),NOB,NU,                                 VE3.7
              6 NOVP,NOVS,NPRX,NPRT,NTPE,NWPC,NKPP,PDX,PDY,PDZ,PI,PRFLM,RDT,    COMM.18
              7 RDX(80),RDY(80),RDZ(80),RRAN(20),SIGMA,ID,TO1,TO2,TFIN,TIMET,TTP,VE3.8
              8 IPL,IPL1,IPR,TPRT,TTO,IWIP,IWTD,UI,UPI,VDI,VDO,VI,VNTP(6),VPI,  COMM.20
              9 VTP,WI,WPI,WRAN(20),X(80),XPCEN,Y(80),YPCEN,Z(80),ZPCEN         VE3.9
                COMMON /MODSET/ SCFLM(200)                                      COMM.22
                COMMON /SAFLM/ XCONV,ZCONV,FX1,FX2,FX3,FX4,FY1,FY2,FY3,FY4,     COMM.23
              1 FXL,FYR,PXL,PYR,IFLP(3),FFX3(75),FFY3(75)                       COMM.24
              2 ,ITCYC(3),XFC1(4),XFC2(4),YFC1(4),YFC2(4),PBTIM(2),XML,YML,ZML  COMM.25
              3 ,IFMID,IEIFST,IPLOPT,IPM(20),IPMM,IPPP,IPROJ,JPM(20),JPMM,JPPP, COMM.26
              4 KPM(20),KPMM,KPPP,NEC,NMC,NPS,NPV,PEC(10),PMC(10),YCONV         COMM.27
              5 ,IFLAB,IFLIN,IFPNT,IFOPT,NCH,XFSP,XT,YFSP,YT                    COMM.28
                COMMON /ZLAST/ ZLAS                                             COMM.29
          C                                                                     COMM.30
                EQUIVALENCE (A(1),U),(A(2),V),(A(3),W),(A(4),P),(A(5),CQ),      EQUIV.2
              1 (A(6),CQF), (A(7),VOL)                                          EQUIV.3
                EQUIVALENCE (C(1),TA,QCON)                                      EQUIV.7
          C                                                                     EQUIV.8
          C ***** THIS SUBROUTINE VRTAP HANDLES BOTH MAG TAPE READ AND WRITE    VARP.2720
              1 FORMAT(1H ,19H TAPE FILE NUMBER =,I4,9H  TIMET =,1PE12.5,16H  CYCLVARP.2721
               1E NUMBER =,I6)                                                  VARP.2722
              2 FORMAT(7HTIMET =,1PE11.4,7H NCYC =,I5)                          VARP.2723
             50 IF( IRW.EQ.0 ) GO TO 500                                        VARP.2724
          C ***** THIS SECTION , 100-300 , WRITES MAG TAPE FILES                VARP.2725
     2      100 ITW=7                                                           VARP.2726
     3          WRITE(ITW) BUFL                                                 VARP.2727
    10          WRITE(ITW) (A(I),I=1,BUFL)                                      VARP.2728
    16          WRITE(ITW) (PTM(I),I=1,LPARTC)                                  VE3.221
    25          WRITE(VDO,1) TO,TIMET,NCYC                                      VARP.2729
    37          ENCODE(30,2,XIDFM) TIMET,NCYC                                   VARP.2730
```

```
VRIAP
   51          GO TO 200                                                 VARP.2731
   52     150  TD=0                                                      VARP.2732
   53          END FILE ITM                                              VARP.2733
   55          REWIND 7                                                  VARP.2734
   57     200  GO TO 999                                                 VARP.2735
        C ***** THIS SECTION , 500-600 , READS MAG TAPE FILES            VARP.2736
   60     500  REWIND 8                                                  VARP.2737
   62          TD1=IBR                                                   VARP.2738
   63          ITPFL=KBR                                                 VARP.2739
   65     550  PRINT 603, ITPFL ,TD                                      VARP.2740
          603  FORMAT( 1H ,6HITPFL=,I2, 5X,3HTD=,I2)                     VARP.2741
   75          READ(8) BUFL                                              VARP.2742
  102          READ(8) (A(I),I=1,BUFL)                                   VARP.2743
  110          READ(8) (PIM(I),I=1,LPARIC)                               VE3.222
  117          IT=ITPFL-TD                                               VARP.2744
  121          IF( IT ) 600,575,550                                      VARP.2745
  123     575  WRITE(VPO,1) TD,TIMET,NCYC                                VARP.2746
  135          ENCODE(30,2,XIDEM) TIMET,NCYC                             VARP.2747
  147          CALL FILMCU                                               VARP.2748
  150          IPLIF=0                                                   VARP.2749
  151          DRUM= 90.                                                 VF3.223
  153          CALL VKIO                                                 VARP.2750
  154          TFIN= TFIN+DT                                             VF3.224
  156          IPLT= IPLT+DT                                             VE3.225
  157          TMID= 3.0E+06                                             VF3.226
  160          IICR=0                                                    VARP.2751
  161          GO TO 999                                                 VARP.2752
  162     600  WRITE(VPO,601)                                            VARP.2753
          601  FORMAT(1H ,58H *** ERROR 004 - TAPE RESTART FILE NUMBER IS INCORREVARP.2754
              1CT ***)                                                   VARP.2755
  166          ERF=1                                                     VARP.2756
  167     999  RETURN                                                    VARP.2757
  170          END                                                       VARP.2758


 SUBPROGRAM LENGTH

 00301

 FUNCTION ASSIGNMENTS

 STATEMENT ASSIGNMENTS
 1       - 000179    2       - 000205    50      - 000002    100     - 000003    150     - 000053    200     - 000060
 500     - 000061    550     - 000066    575     - 000124    600     - 000163    601     - 000224    603     - 000215
 999     - 000170

 BLOCK NAMES AND LENGTHS
   *LCMR- 0072460
 VRCOM   - 106240/01  COMCEN  - 000132/02  AMIX    - 001130/03  FL      - 000035/04  FLS     - 000011/05  VRCON   - 006352/06
 MUDSET  - 000310/07  SAFLM   - 000447/00  ZLAST   - 000001/11

 VARIABLE ASSIGNMENTS
 A       - 000000/01  BKGS    - 000036/02  BUFL    - 000009/06  C       - 000000/05  CPRT    - 000244     CQ      - 000009/01
 COF     - 000005/01  DROU    - 000435/06  DT      - 000006/06  DX      - 000007/06  DY      - 000130/06  DZ      - 000251/06
 ENF     - 000374/06  F       - 000241     FACS    - 000050/02  FH      - 000024/04  FFX3    - 000021/08  FFY3    - 000139/08
```